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ABSTRACT

The Learning Equation (TLE) is a software product that provides mathematics programming to students. It was introduced to grade 9 students in Alberta in 1997-1998, and in 1998-1999, its use was extended to grades 7, 8, and 10. TLE is designed to follow the Alberta mathematics curriculum closely. It can be implemented in several ways, and in some schools is the main delivery method, entirely replacing textbooks. In other schools, it is a supplement or a remedial resource. This study examined the effects of TLE on student achievement and attitudes and on teachers' effective delivery of mathematics. Interviews were conducted with 1,186 students, and data, including achievement findings, were available from several sources. Overall, by grade 9, students who used TLE slightly outperformed those who did not. TLE did not appear to make students feel more positive about mathematics, but in some cases, it reduced negative feelings. Teachers reported positive attitudes about TLE, but wished for closer communication with the TLE development community. In general, study findings reflect positively on TLE and indicate that it is a viable alternative to teaching mathematics using a textbook. Three appendixes describe study methodology and present pretest and posttest student responses. (Contains 17 tables and 23 graphs.) (SLD)

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THE LEARNING EQUATION (TLE)

FINAL REPORT

JANUARY 2002

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Executive Summary

Introduction

The Learning Equation (TLE) is a software product that provides mathematics programming to students. It was introduced at the Grade 9 level in Alberta in 1997/98. In 1998/99 its use was extended to Grades 7, 8 and 10. TLE was developed in cooperation with Nelson Canada; Alberta Learning provided both financial support and developmental/curricular assistance. TLE closely follows the Alberta mathematics curriculum.

TLE can be implemented in a variety of ways. In some schools, for example, TLE is used as the main delivery method, entirely replacing textbooks. In others it is used as a supplementary (i.e. used for selected units) or remedial resource. Though TLE was not intended for use as a stand-alone program for virtual education, it appears that it is being used that way in some schools.

In 2000, Alberta Learning initiated a study to examine the impact of TLE on students and teachers. This study examined the following three goals of TLE:

- Increase student achievement in mathematics
- Positively influence students' attitudes towards mathematics
- Assist teachers with the effective delivery of mathematics.

Each of the three goals was examined separately through analysis of student achievement and attitudes and TLE teacher's experiences. Both quantitative and qualitative research methodologies were used to explore the impact of TLE on student achievement and its effect on students' perceptions of mathematics and teachers' satisfaction with the effectiveness of TLE in assisting with mathematics instruction.

Relationship to Alberta Learning's Business Plan

This project relates to Alberta Learning's business plan in two key ways:

Goal 1: High Quality Learning Opportunities

- Outcome: Responsiveness and Flexibility: The learning system is flexible and provides a variety of programs and modes of delivery

Goal 5: Highly Responsive and Responsible Ministry

- Outcome: The Ministry demonstrates leadership and continuous improvement in administrative and business processes and practices

Summary of Findings

Student Achievement

The 1996/97 Grade 6 and 1999/00 Grade 9 Mathematics Provincial Achievement Tests were used to examine the achievement of students who used TLE in Grade 9 and those who did not. Overall, students who used TLE in Grade 9 slightly outperformed their non-TLE counterparts.

The following table presents the 1996/97 Grade 6 and 1999/00 Grade 9 Mathematics Achievement Test results by TLE usage. In interpreting these results, it should be noted that students are divided into TLE and non-TLE groups based on their mode of instruction in Grade 9 – neither group used TLE in Grade 6. At the Grade 6 level the two groups were very similar. Approximately equal proportions of the TLE (90.9%) and non-TLE groups (91.2%) achieved the acceptable standard on the Grade 6 Mathematics Achievement Test. Twenty-six percent of each group achieved the standard of excellence. The mean scores[1] of each group were also remarkably similar – 35.2 for the TLE group and 35.1 for the non-TLE group. The difference between the groups' Grade 6 mean scores was not statistically significant.

By Grade 9, the achievement of the TLE and non-TLE groups is different. The TLE group has a significantly higher mean score and a significantly greater proportion of students achieving the standard of excellence. The two groups are not significantly different at the acceptable standard. Overall, the 1.2 raw score point difference in the average scores is statistically significant and indicates that TLE students outperformed their non-TLE counterparts.

Mathematics Achievement Test Results						
	Grade 6: 1996/1997			Grade 9: 1999/2000		
	TLE Group	Non-TLE Group	Province	TLE Group	Non-TLE Group	Province
Number	1 658	21 874	38 764**	1 658	21 874	37 419**
Mean Score	35.2	35.1	34.1	31.4*	30.2*	30.0
Standard Deviation	8.5	8.4	9.0	10.5	10.1	10.3
% Achieving Acceptable	90.9	91.2	87.7	76.7	75.0	73.6
% Achieving Excellence	26.2	26.2	24.4	20.3*	15.7*	15.7

*Difference between TLE and non-TLE groups is statistically significant, $p<.01$

**The TLE and non-TLE groups are not equal to the total number of students in the province because some students were omitted from the analysis. Please see Appendix 1 for and explanation of the omissions.

[1] The maximum possible score for these 2 mathematics Achievement Tests was 50.

The major component of the student achievement analysis involved using linear regression to predict students' 1999/00 Grade 9 Mathematics Provincial Achievement Test score based on their 1996/97 Grade 6 Mathematics score[2]. This technique is useful because it takes into account the prior achievement level of students when analyzing current results. Grade 6 mathematics scores of non-TLE students were used to predict what a student would be expected to achieve in Grade 9. This, in effect, meant that non-TLE students were used as a control group. The results of this analysis showed that the TLE students significantly outperformed expectations. As the following table shows, TLE students scored 1.04 raw score points higher than predicted[3].

Differences in Achievement Test Raw score points Using/Not Using TLE

	Number	Predicted Grade 9 Mean	Actual Grade 9 Mean	Difference (Actual – Predicted)
Using TLE	1 658	30.32	31.36	1.04*
Not using TLE	21 874	30.24	30.24	N/A

*p<0.01

Student Survey

Junior high students using TLE for the first time, and a control group who did not use TLE, were surveyed about their attitudes towards mathematics in September 2000 and then again in May 2001. Survey results were analyzed according to three concepts – confidence in mathematics ability, attitudes towards mathematics and motivation.

While results are somewhat mixed, the experimental group appears to have obtained some "buffering" effects from TLE. While TLE does not appear to have caused students to feel more positive towards mathematics, it seems that it did, in some cases, help to prevent them from feeling more negative. While motivation decreased across all groups, confidence in mathematics ability and attitudes towards mathematics were maintained in the TLE group. Only amongst Grade 7s using TLE were decreases seen across all scales.

Confidence, Attitude and Motivation Changes in TLE and Non-TLE Students

	TLE			Non-TLE		
	Confidence	Attitudes	Motivation	Confidence	Attitudes	Motivation
Overall	**No change**	**No change**	Decrease	Decrease	Decrease	Decrease
Grade 7	Decrease	Decrease	Decrease	**No change**	Decrease	Decrease
Grade8	**No change**	**No change**	Decrease	Decrease	Decrease	Decrease
Grade 9	**No change**	**No change**	Decrease	**No change**	**No change**	Decrease
Females	**No change**	**No change**	Decrease	**No change**	Decrease	Decrease
Males	**No change**	**No change**	Decrease	Decrease	Decrease	Decrease

In addition to comparing results between TLE and non-TLE students, the survey also obtained feedback about the program from TLE students. This analysis showed that students who used TLE more frequently (more than 3 times/week) were more likely to have positive attitudes towards mathematics, computers and TLE, itself than did students who used TLE less frequently (less than 3 times/week).

[2] See the "Student Achievement Analysis" section of Appendix 1 for a detailed description of the methodology.

[3] The maximum possible score on this mathematics Achievement Tests was 50.

Teacher Focus Groups

Overall, teachers were very positive about their TLE experiences and thought their students benefited from this new form of instructional delivery. Many perceived positive attitudinal changes in their students. In addition, teachers thought they benefited from the opportunity to employ creative and innovative teaching strategies and their students also benefited from this. Focus group participants thought TLE allowed students to work at their own pace and provided teachers with an opportunity for more one-on-one and small group instruction. The vast majority of focus group participants agree TLE works best for mid-level students. There was some concern that it was not ideally suited to other groups such as below average and modified program students.

While teachers were generally happy about what is occurring in their classroom, many thought additional supports are needed. Almost uniformly, teachers thought both Alberta Learning and Nelson could facilitate more effective communication within the TLE community. In part, this should include the key component of receiving in-service prior to implementing TLE; a factor many participants thought was necessary for successful TLE implementation. Teachers expressed the desire to maintain a close, continuous relationship with the software developer.

Teachers were also careful to point out the key role that teacher motivation plays in TLE implementation. In terms of a teacher making a decision to start with TLE, the focus group participants thought using TLE "is not for everyone." In a few cases, teachers were directed to use TLE by the school administration. Not surprisingly, this seemed to increase the chances of having a negative TLE experience.

Another important aspect of TLE implementation is having adequate technology. Schools without adequate technical support were finding TLE implementation very difficult. For those who had adequate support, however, TLE offered an opportunity to bring a new and exciting form of learning to the classroom.

Observations

Some key observations that should be considered when implementing TLE were noted during the course of the study:

- Administrative support at both the school and school authority levels is crucial for successful TLE implementation. This is especially important in terms of ensuring sufficient technical resources are available.
- TLE may be particularly useful to non-specialist math teachers because it can complement their instruction with another perspective.
- The minimum technical standards specified for TLE may not be acceptable to many students – 42% of grade sevens, 37% of grade eights and 42% of grade nines thought that their computers were too slow.

In addition, consideration should also be given to the reading ability of students. The amount of reading required by TLE may be difficult for some students and suggests that TLE could be improved by additional audio support (in order to decrease the visibility of students who need to use audio support, some teachers suggested that all students be allowed to bring CDs into class).

Recommendations

For schools/school authorities:

1. Teacher support is obtained prior to TLE implementation. Efforts to implement TLE without full teacher support were generally not positive.

2. Teachers are provided with the opportunity to attend in-service prior to TLE implementation. Many teachers found this to be an extremely useful part of TLE preparation.

3. Schools should have sufficient technical infrastructure prior to TLE implementation. This allows teachers and students to focus on mathematics without the distractions and delays caused by crashing computers, etc.

For Alberta Learning:

4. Alberta Learning support the provision of information about TLE resources to teachers in order to facilitate better communication with the TLE community.

5. Alberta Learning continue to support the development of TLE.

6. This study be made available to school and school authority staff to inform programming decisions.

Future Research

The current study provides a broad overview of the relationship between TLE and student achievement and attitudes. It cannot, however, definitively isolate the unique effect of TLE on these factors. While this study showed an overall increase in achievement by TLE students, additional information on student characteristics would be helpful in interpreting these achievement gains – do all, or only some types, of students benefit from using TLE? Future research may want to focus on a more detailed investigation of TLE use in the classroom. Investigation of successful models of TLE implementation could be particularly useful in developing "best practices" guidelines.

Conclusion

In general, the overall results of this study reflect positively on TLE. The results of this study suggest that while TLE is not the answer to all mathematics issues, it should be considered a viable alternative to teaching mathematics using a textbook. For one, TLE offers an innovative way for students to learn and teachers to teach mathematics. In addition, TLE students in this study felt less negative about Mathematics than non-TLE students. Lastly, while this study cannot answer all of the questions surrounding the relationship between TLE and student achievement, it does suggest that, at a general level TLE may positively impact achievement for some students.

Student Achievement Analysis

Introduction

A key goal of this study was to examine the role of TLE in student achievement. In order to determine the impact that TLE has had on student achievement, linear regression, was used to predict students' 1999/00 Grade 9 Mathematics Provincial Achievement Test (PAT) scores based on their 1996/97 Grade 6 Mathematics PAT scores. This technique examines students' current achievement *net* of their prior achievement. Only students with both 1996/97 Grade 6 and 1999/00 Grade 9 Mathematics PAT scores were included in the analysis.

Students were assigned to TLE and non-TLE groups based on information provided by Nelson Canada and obtained through telephone interviews with school staff. Those schools where students *may* have been using TLE were classed as "indeterminate" and largely removed from the analysis. The 1996/97 Grade 6 (independent variable) and 1999/00 Grade 9 (dependent variable) Mathematics PAT scores of students who were not using TLE were used to generate a regression equation. This equation was then used to generate *estimated* Grade 9 scores for each TLE student using their actual 1996/97 Grade 6 Mathematics PAT results. In total, 1 658 students were included in the TLE group and 21 874 students were included in the non-TLE group.

In interpreting the achievement results it is important not to confuse correlation and causation. While the results indicate that TLE students scored higher than expected, this does not automatically lead to the conclusion that the achievement gain was *due* to TLE.

Grade 6 and 9 Mathematics Achievement Test Results

Prior to running the predictive regression, descriptive statistics on the 1996/97 Grade 6 and 1999/00 Grade 9 Mathematics PATs for the TLE and non-TLE groups were examined. The following table presents the Grade 6 and 9 Mathematics PAT results by TLE usage. For both groups, a lower proportion of students attain the acceptable standard and the standard of excellence on the grade 9 test than on the grade 6 test. At the Grade six level the two groups were very similar. Approximately equal proportions of the TLE (90.9%) and non-TLE groups (91.2%) achieved the acceptable standard on the Grade 6 Mathematics PAT. 26.2% of each group achieved the standard of excellence. The mean scores[4] of each group were also remarkably similar – 35.2 for the TLE group and 35.1 for the non-TLE group. The difference between the groups' grade 6 mean scores was not statistically significant.

By grade 9, the achievement of the TLE and non-TLE groups is different. The TLE students are outperforming their non-TLE counterparts at the standard of excellence by 4.6%. In addition, at the Grade 9 level, the difference between the mean raw score points of the two groups (1.2) is statistically significant[5].

[4] The maximum possible score for these 2 mathematics Achievement Tests is 50.
[5] Based on an independent samples t-test.

Mathematics Achievement Test Results						
	Grade 6: 1996/1997			Grade 9: 1999/2000		
	TLE Group	Non-TLE Group	Province	TLE Group	Non-TLE Group	Province
Number	1 658	21 874	38 764	1 658	21 874	37 419
Mean Score	35.2	35.1	34.1	31.4*	30.2*	30.0
Standard Deviation	8.5	8.4	9.0	10.5	10.1	10.3
% Achieving Acceptable	90.9	91.2	87.7	76.7	75.0	73.6
% Achieving Excellence	26.2	26.2	24.4	20.3*	15.7*	15.7
*Difference between TLE and non-TLE groups is statistically significant, $p<0.01$						

Regression Analysis

A predictive regression equation was generated based on the Grade 6 and 9 Mathematics PAT scores of students who did not use TLE. In general terms, the regression equation represents what the "average" student would be expected to accomplish. Each student's grade 6 score is put into the equation to generate a predicted grade 9 score. A student's predicted score is then compared to his/her actual score to determine if he/she performed above, below or as predicted.

The data collection and analysis procedures used to generate the regression equation were as follows:

- The 1996/97 Grade 6 Mathematics PAT scores of students *not using TLE* were used to generate a regression equation to predict scores for the 1999/00 Grade 9 Mathematics PAT. This group served as a control group.
- Using the generated regression equation, predicted scores for all students were calculated. The actual 1999/00 Grade 9 Mathematics PAT scores of the TLE group were then compared to their predicted raw scores. (Note: Because students in the non-TLE group were used to generate the predicted scores, as a group their difference from the prediction is zero.)

The non-TLE Grade 6 scores (the independent variable) explained approximately ½ ($R^2=0.512$) of the variation in the Grade 9 scores (the dependent variable). Additional variables added to the regression equation – e.g. gender – did not substantially change the R^2 value, and, hence were omitted from the equation.

The remainder of this section compares the actual results of the TLE group to their predicted results using a t-test to determine if there are significant differences.

As the following table illustrates, students using TLE scored, on average, 1.04 raw score points higher than predicted. This translates to a gain of approximately 2%.

Differences in Achievement Test Scores Using/Not Using TLE				
	Number	Predicted Grade 9 Mean	Actual Grade 9 Mean	Difference (Actual – Predicted)
Using TLE	1 658	30.32	31.36	1.04*
Not using TLE	21 874	30.24	30.24	N/A
*$p<0.01$				

Using TLE as a Primary Resource

Teachers can use TLE in a variety of ways. To further explore the effect of TLE, teachers were asked to provide additional information on exactly how they were using TLE in their classroom. One of the ways teachers can use TLE is as a "primary resource", that is TLE (including the student refresher) is used instead of a textbook. Forty two per cent (N=697) of the sample used TLE as a primary resource. The actual Grade 9 mean for this group of students was 1.20 raw score points above that which was predicted (a 2.4% gain).

Table 3
Using TLE as a Primary Resource

	Number	Predicted Grade 9 Mean	Actual Grade 9 Mean	Difference Score (Actual – Predicted)
Primary TLE use	697	30.04	31.24	1.20*
*p<0.01				

Using TLE as a Supplementary Resource

Fifty eight per cent (n=961) of our sample was using TLE as a "supplementary resource": Students accessing TLE in this manner would typically be spending less time on TLE than those using it as a primary resource. Supplementary TLE use can be defined as follows:

- Selected strands or lessons – TLE is used for all of a particular topic area (strand) or for all of the material in selected lessons within a strand.
- Blended with textbook – some portion of the lesson is given using traditional delivery and some is delivered using TLE, often this group spends one or a few days a week in the lab.

Those using TLE as a supplementary resource scored 0.93 raw score points above the prediction for their group.

Using TLE as a Supplementary Resource

	Number	Predicted Grade 9 Mean	Actual Grade 9 Mean	Difference Score (Actual – Predicted)
Supplementary TLE use	961	30.52	31.45	0.93*
*p<0.01				

Gender

Analyzing the sample according to gender revealed positive TLE-related score differences for both males and females. Both male and female TLE users significantly outperformed their non-TLE counterparts; in both cases the difference was approximately 1 raw score point.

Gender Differences
TLE/non-TLE

	Number	Predicted Grade 9 Mean	Actual Grade 9 Mean	Difference Score (Actual – Predicted)	TLE – non TLE
Males using TLE	855	31.06	31.98	0.92	1.19*
Males not using TLE	11 174	30.88	30.62	-0.27	
Females using TLE	803	29.52	30.70	1.17	0.90*
Females not using TLE	10 700	29.57	29.84	0.27	
*p<0.01					

Achievement Level

In order to investigate the hypothesis that TLE has a different effect for students of differing achievement levels the performance of "high", "average" and "below average" achieving students using TLE to similar students who were not using TLE was compared. Students were divided into achievement groups based on their performance on the 1996/97 Grade 6 Mathematics PAT.

In general, the performance of the TLE group is somewhat higher at every achievement level. In contrast to the hypothesis, however, there is very little difference across the differing achievement levels, i.e. the impact of TLE appears similar at all levels of achievement[6].

High Achievers

Students who had attained the standard of excellence on the 1996/97 Grade 6 Mathematics PAT were divided into TLE and non-TLE groups. The achievement of these two groups on the 1999/00 Grade 9 Mathematics PAT was then compared. As the following table illustrates, the mean scores of these two groups was significantly different at grade 9 but not at grade 6.

The regression analysis was also run specifically for high achievers. When comparing the actual and predicted raw score points of the TLE and non-TLE groups, the TLE group again significantly outperformed the non-TLE group (by 1.09 raw score points)[7].

Mathematics Achievement Test Results
High Achievers

	Grade 6: 1996/1997		Grade 9: 1999/2000	
	TLE Group	**Non-TLE Group**	**TLE Group**	**Non-TLE Group**
Number	435	5 732	435	5732
Mean Score	45.06	44.87	40.62*	39.53*
Standard Deviation	2.25	2.18	6.79	6.71

*Difference between TLE and non-TLE groups is statistically significant, $p<0.01$

Average Achievers

The 1999/00 Grade 9 Mathematics PAT performance of TLE and non-TLE students who had attained the acceptable standard, but not the standard of excellence, on the 1996/97 Grade 6 Mathematics PAT was also examined. Significant differences (refer to the table below) were seen on the mean score of the TLE and non-TLE students at the Grade 9 level.

When comparing the differences between actual and predicted scores between the TLE and non-TLE groups, TLE students outperformed non-TLE students by 1.07[8] raw score points.

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[6] In addition to the information presented in the following tables, an analysis of variance – which confirmed that TLE functioned similarly at all achievement levels - was run.

[7] The difference in predicted and actual raw score points between the TLE and non-TLE group is calculated as: $(TLE_{actual} - TLE_{predicted}) - (\text{non-}TLE_{actual} - \text{non-}TLE_{predicted})$.

[8] The difference in predicted and actual raw score points between the TLE and non-TLE group is calculated as: $(TLE_{actual} - TLE_{predicted}) - (\text{non-}TLE_{actual} - \text{non-}TLE_{predicted})$.

Mathematics Achievement Test Results Average Achievers				
	Grade 6: 1996/1997		Grade 9: 1999/2000	
	TLE Group	Non-TLE Group	TLE Group	Non-TLE Group
Number	1 072	14 222	1 072	14 222
Mean Score	33.45	33.33	29.36*	28.19*
Standard Deviation	5.30	5.19	9.15	8.56
*Difference between TLE and non-TLE groups is statistically significant, $p<0.01$				

Below Average Achievers

The performance of below average achievers - students who did not attain the acceptable standard on the 1996/97 Grade 6 Mathematics PAT – was not significantly different at the grade 6 level between students using and not using TLE. By grade 9, however, the mean scores of the two groups were (statistically) significantly different.

The results of the regression analysis also showed the TLE students outperforming non-TLE students. In comparing predicted to actual results, TLE students fared 1.08[9] raw score points better than non-TLE students.

Mathematics Achievement Test Results Below Average Achievers				
	Grade 6: 1996/1997		Grade 9: 1999/2000	
	TLE Group	Non-TLE Group	TLE Group	Non-TLE Group
Number	151	1 920	151	1 920
Mean Score	18.78	18.67	18.86*	17.68*
Standard Deviation	2.89	3.17	6.45	6.79
*Difference between TLE and non-TLE groups is statistically significant, $p<0.05$				

School Results

Predictions of student performance on the 1999/00 Grade 9 Mathematics PAT were also generated at the school level. In total, 26 schools using TLE had enough students (at least 20) to examine results at this level. Of these 26, 15 had results above predicted and 9 had results below. Sixteen schools had results significantly different than predicted; 9 were significantly above and 7 were significantly below. These results illustrate that TLE functions differently across schools and is, of course, but one aspect of instructional delivery.

[9] The difference in predicted and actual raw score points between the TLE and non-TLE group is calculated as: $(TLE_{actual} - TLE_{predicted}) - (\text{non-}TLE_{actual} - \text{non-}TLE_{predicted})$.

Summary

Overall, TLE students slightly but consistently outperform the non-TLE group in all categories. This steady trend in the data may suggest a general positive effect of using TLE on students' mathematics achievement. However, as noted previously, these findings should be interpreted with caution as a *relationship*, not a causal conclusion. There is a possibility that, besides influences of the TLE program, some other factors beyond the control of this study could affect students' achievement. For example, teacher focus groups revealed that TLE teachers considered themselves to be more innovative and willing to put more work into their classes than some other teachers. Therefore TLE students might perform better than their non-TLE counterparts not because (or not only because) of the program but because they have highly motivated teachers. In addition, by virtue of having TLE in-service, TLE teachers may have had access to additional math in-service opportunities that non-TLE teachers have not had.

Student Survey Analysis

Introduction

In order to examine the effect of TLE on students' opinions about mathematics, a survey was administered to TLE and non-TLE (control) students in September 2000 and May 2001. The TLE students were using TLE for the first time. As such, the design permitted measuring students' opinions towards mathematics prior to and after TLE exposure. In addition, the control group information provides contextual information against which to judge the TLE group's results.

The purpose of the questionnaire was twofold: it allowed the comparison of opinions towards mathematics in TLE and non-TLE students and obtained information from TLE students about their experiences with the program.

Since the analysis is divided by TLE use, gender and Grade, for the purpose of reliability only cases with complete information on these variables were included in the analyses. There were 1186 complete cases available for analysis. These cases are split across gender and Grade levels equally. There are 598 (50.4%) male students and 588 (49.6%) female students in the study. Four hundred and five (34.1%) grade sevens, 382 (32.2%) grade eights and 399 (33.6%) grade nines are included in this analysis.

Student Confidence, Attitudes and Motivation

The TLE questionnaire primarily consists of three scales designed to measure students' *confidence* in their ability to do mathematics, their *attitudes* towards the study of mathematics and their *motivation* to do well in mathematics.

The motivation scale consists of questions surrounding the perceived importance of mathematics and the effort necessary to be successful. A scale regarding the TLE students' attitudes about using computers was also calculated, however variables included in this scale are from the pre-test questionnaire only.

Scale reliabilities were determined using Cronbach's alpha[10]. The following table shows the questions that comprise each scale and the corresponding reliability coefficient. Each scale was calculated by summing item raw score points so that a high score indicates a high level on that factor. Scale items containing an 'R' in the question number were recoded so that the responses were coded in the same direction.

[10] Alpha measures the extent to which item responses obtained at the same time correlate highly with each other.

Scale Descriptions	
Scale 1. - Student CONFIDENCE in their math ability (11 Items, Pre-test Alpha = 0.91 & Post-test Alpha = 0.91)	
Q10R	Math makes me feel confused
Q14R	Math is harder for me than for most people
Q19	I have been successful in solving difficult math problems
Q20R	Usually, when I do not know the answer to a question right away, I try to guess
Q22R	No matter how hard I try, I cannot understand math
Q25R	Math is a difficult subject for me
Q26	I am as good at math as most other students
Q27	Others could ask me a math question, and I could usually answer it
Q29R	I am not the type to do well in math
Q31	I am confident that I will obtain a 65 or better in math
Scale 2. - Student ATTITUDES regarding the study of math. (5 Items, Pre-test Alpha = 0.88 & Post-test Alpha = 0.88)	
Q6R	Math is boring
Q8R	I do not like going to math class
Q13	Math is fun
Q18R	Math is one of my most dreaded subjects
Q24	I like math
Scale 3. 11 Items - Student MOTIVATION to Do Well in Math (Importance & Effort Variables) (Pre-test Alpha = 0.74 & Post-test Alpha = 0.77)	
Q9	Math is important in everyday life
Q11	Everyone can do math if he/she tries hard enough
Q12R	Math is important only to math teachers
Q15	It is important to do well in math at school
Q16	I try to explore different ways to solve a math problem
Q17	I feel I will do better in math this year
Q21	I think I will need to do well in math to get a good job
Q23	I spend as much time as it takes on a problem in order to complete it
Q28	Usually, when I do not know the answer to a question right away, I try to figure it out
Q30R	If a math assignment is too hard, I often stop working on it altogether
Q32R	Math is not very important outside of school
Scale 4. - Attitudes regarding the use of COMPUTERS (5 Items, Pre-test Variables ONLY Alpha = 0.89)	
Q43	I am looking forward to using computers in my math class this year
Q44	Using a computer in math class will be fun
Q45	Using a computer in math class will help me learn math
Q46R	I don't want to use a computer in math class
Q47R	I don't think I will do well in a math class that uses computers

There was a general decrease in confidence, attitudes and motivation regarding the study of mathematics between the pre-test and post-test for the entire sample. Motivation decreased significantly overall and across gender, grades, and treatment groups. Since the post-test was distributed near the end of the year these

results are not surprising and can likely be attributed to year-end fatigue, a phenomena noted by focus group participants.

When TLE and non-TLE groups are examined separately, differences in pre and post-test confidence in mathematics ability and attitudes towards mathematics are evident. In terms of confidence and attitudes, there was a significant decrease in both factors for students who did not use TLE. In contrast, students using TLE showed no significant decrease in attitude or confidence regarding mathematics. Motivation levels showed significant decreases for both groups.

Results for the TLE and non-TLE groups were also analyzed by grade. These results seemed mixed with more positive results for the grade seven non-TLE group and grade eight TLE group. Grade nine students in both the TLE and non-TLE groups did not show significant changes in their attitudes and confidence. For grade seven students there was a significant decrease in attitudes about mathematics for both control and TLE groups. There was however, a significant decrease in confidence for the TLE group only. Grade eight students in the control (non-TLE) group showed a significant decrease in both confidence and attitude, while the TLE group showed no decreases in confidence or attitude. There was no difference in confidence or attitudes for grade nine students for either treatment group. As mentioned above motivation decreased across all grade and treatment groups.

When results are examined by gender, there appears to be a general positive effect of TLE. Males in the control group showed significant declines in confidence and attitudes from the pre-test to the post-test. Females in the control group displayed a significant decrease in attitudes regarding mathematics but maintained the same level of confidence from pre-test to post-test. Both male and female students using TLE were less likely to lose their positive attitudes towards mathematics over the year than students attending regular mathematics classes. In addition, male and female TLE students maintained confidence in their mathematics abilities from September – May.

Students using TLE were asked on the pre-test about their attitudes towards using computers in mathematics class. Attitudinal changes were analyzed according to students' original feelings about using computers in mathematics class. Questions about using computers were combined into a scale: Students' scores on this scale could range from 0 – completely negative about computers – to 25 – very positive about computers. Actual scores ranged from 1 to 25. Students with scores of 20-25 were considered to have very positive attitudes towards computers. For those students who expressed more positive feelings towards computers at the pre-test, there were statistically significant drops in attitudes towards mathematics, confidence in mathematics ability and motivation. In contrast, the remainder of students – those who tended to be neutral or negative about using computers in mathematics - had a significant drop only in motivation. This may be explained by the fact that students who were initially very excited about using TLE – possibly conceiving of it as similar to a video game - were disappointed when they realized they still had to do mathematics.

Summary: Student Confidence, Attitudes and Motivation

While results are somewhat mixed, the experimental group appears to have obtained some "buffering" effects from TLE. While TLE does not appear to have caused students to feel more positive towards mathematics, it seems that it did, in some cases, help to prevent them from feeling more negative. While motivation decreased across all groups, confidence in mathematics ability and attitudes towards mathematics were maintained in the (overall) TLE group. Only amongst Grade 7s using TLE were decreases seen across all scales.

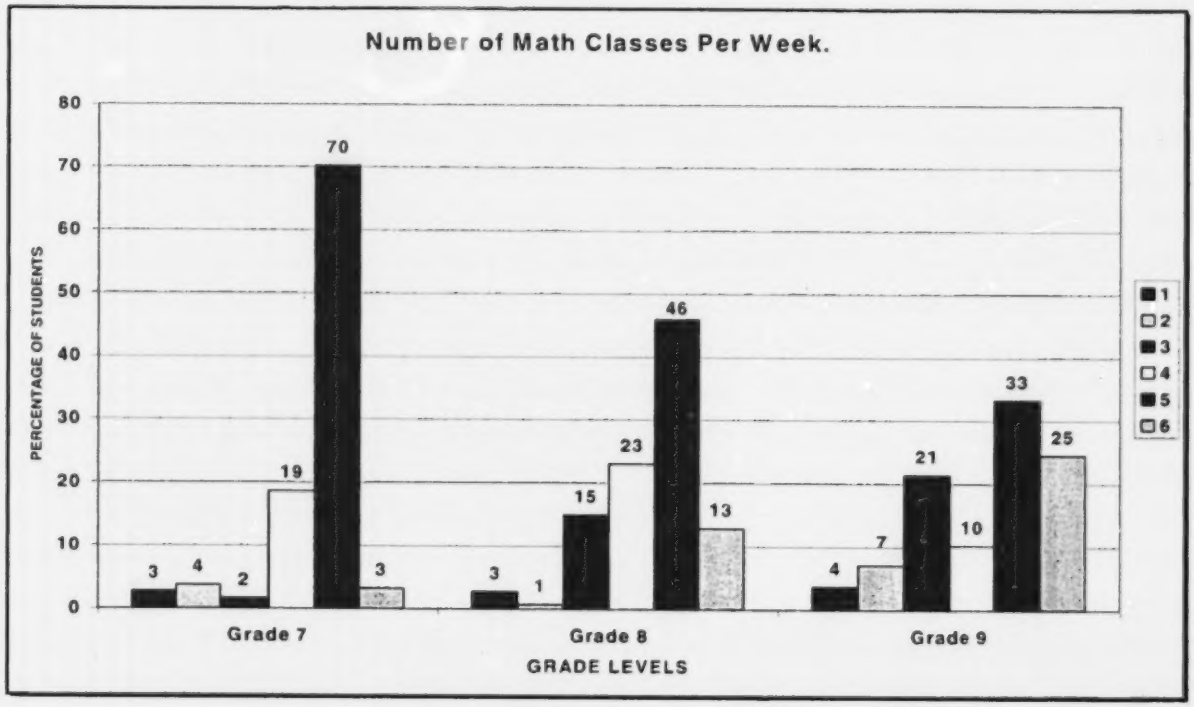
Attitudinal Changes in TLE and Non-TLE Students*						
	TLE			Non-TLE		
	Confidence	Attitudes	Motivation	Confidence	Attitudes	Motivation
Overall	**No change**	**No change**	Decrease	Decrease	Decrease	Decrease
Grade 7	Decrease	Decrease	Decrease	**No change**	Decrease	Decrease
Grade8	**No change**	**No change**	Decrease	Decrease	Decrease	Decrease
Grade 9	**No change**	**No change**	Decrease	**No change**	**No change**	Decrease
Females		**No change**		**No change**	Decrease	Decrease
Males		**No change**		Decrease	Decrease	Decrease

TLE Observations

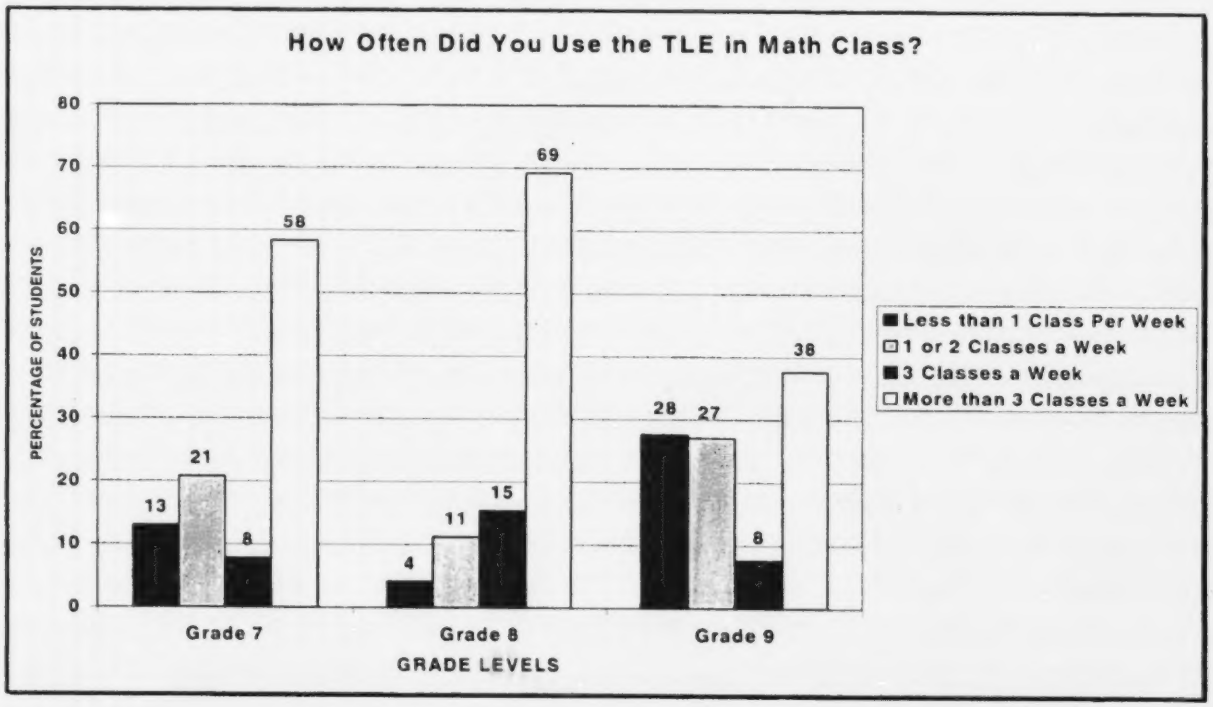
In addition to the comparison of TLE to non-TLE students, the survey asked TLE students' about their experiences with the program. The following charts present these results, by grade.

Survey respondents using TLE typically had 5 or 6 mathematics classes each week.

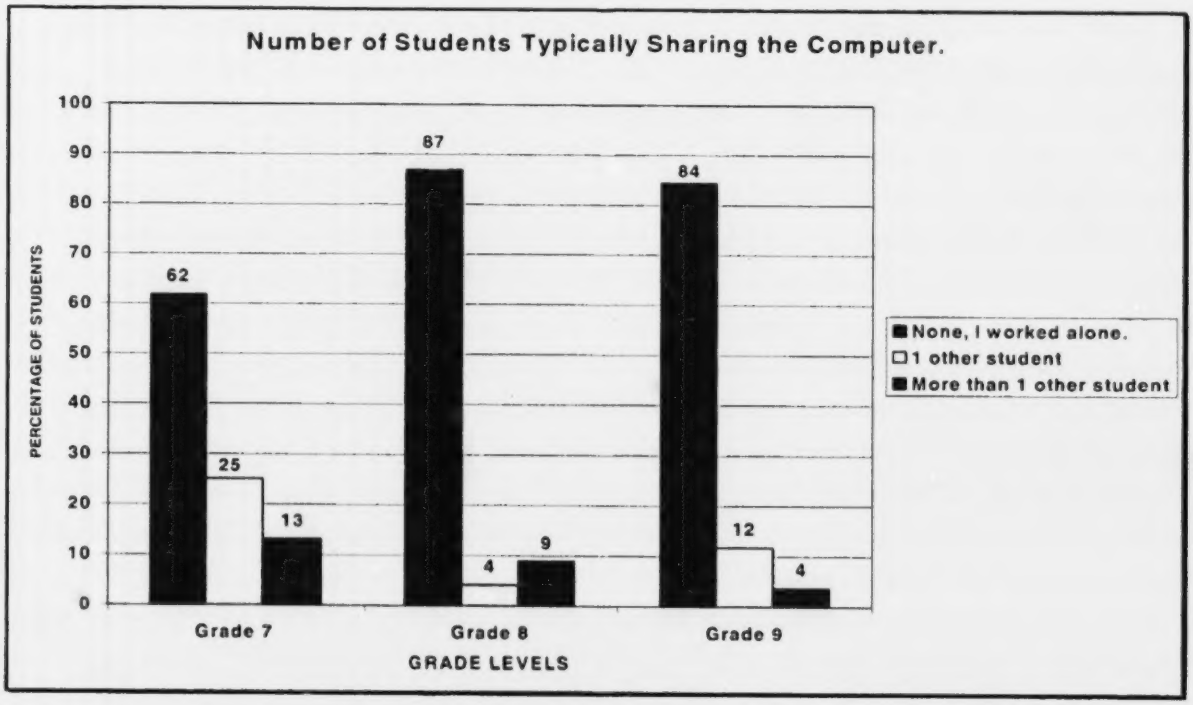
The vast majority of grade 7 students (70%) attend exactly 5 classes of mathematics per week. A lower percentage of grade 8 and 9 students attended exactly 5 classes (i.e., 46% and 33% respectively), however, a sizable proportion of grade 8 and 9 students attend an additional class of mathematics per week (i.e., 13% and 25% respectively).



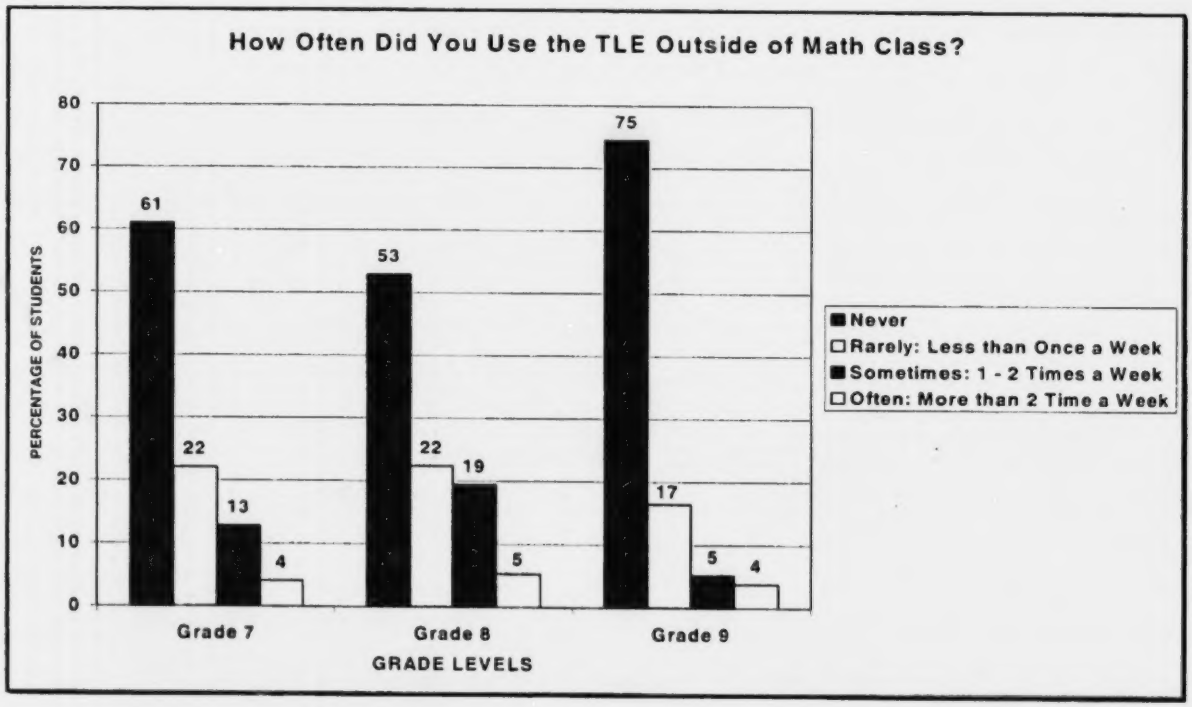
Over two-thirds of grades 7 students (64%) and nearly all grade 8 students (85%) used TLE more than 3 times a week. Less than half of the grade 9 students (46%) used TLE more than 3 times a week.



Grade 8 and 9 students seem to have the opportunity to work alone on a computer most of the time. Grade 7 students seem to be required to team up on computers more often.



The majority of TLE students did not use the program outside of mathematics class. Three-quarters of grade 9 students never use TLE outside of mathematics class. Grade 8 students (24%) are the most likely to use TLE outside of class at least once a week.

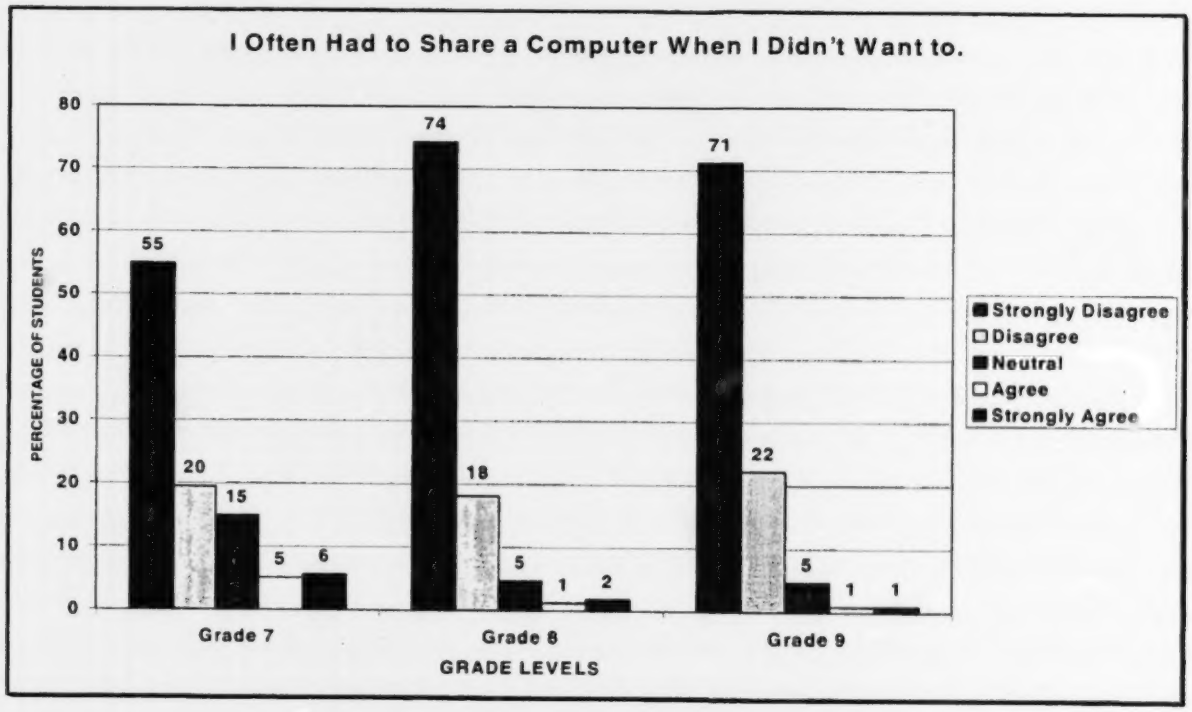


The following figures illustrate student attitudes and feelings about computers, mathematics and using the TLE program. The titles in these figures are the statements from the questionnaire. Students were asked how much they agreed with these statements. The graph values represent the percentage of students endorsing each agreement category on a 5-point likert scale (i.e. Strongly Disagree, Disagree, Neutral, Agree, and Strongly Agree).

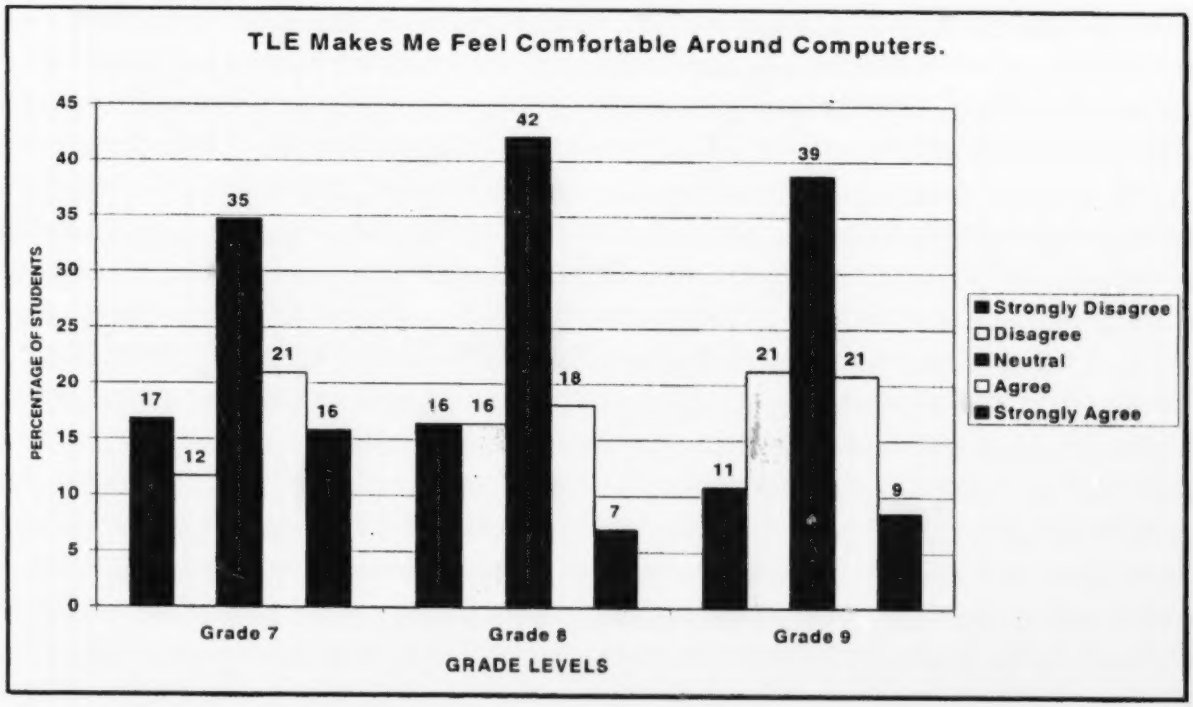
Computers

The distribution of student attitudes regarding the sharing of computers mirrors the previous figure, which illustrated the availability of computers.

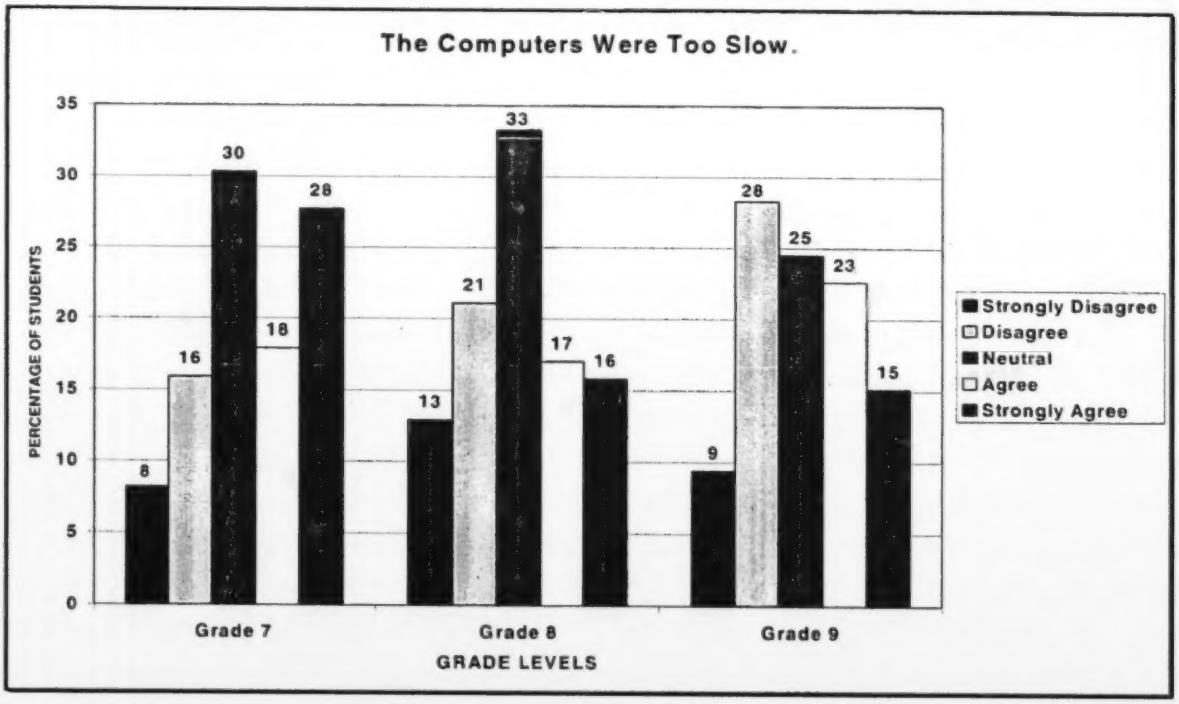
Only a very small proportion of grade 8 and 9 students (i.e., 3% and 2%, respectively) agreed with the statement that they often had to share a computer when they did not want to. A slightly higher proportion of grade 7s (11%) agreed with this statement.



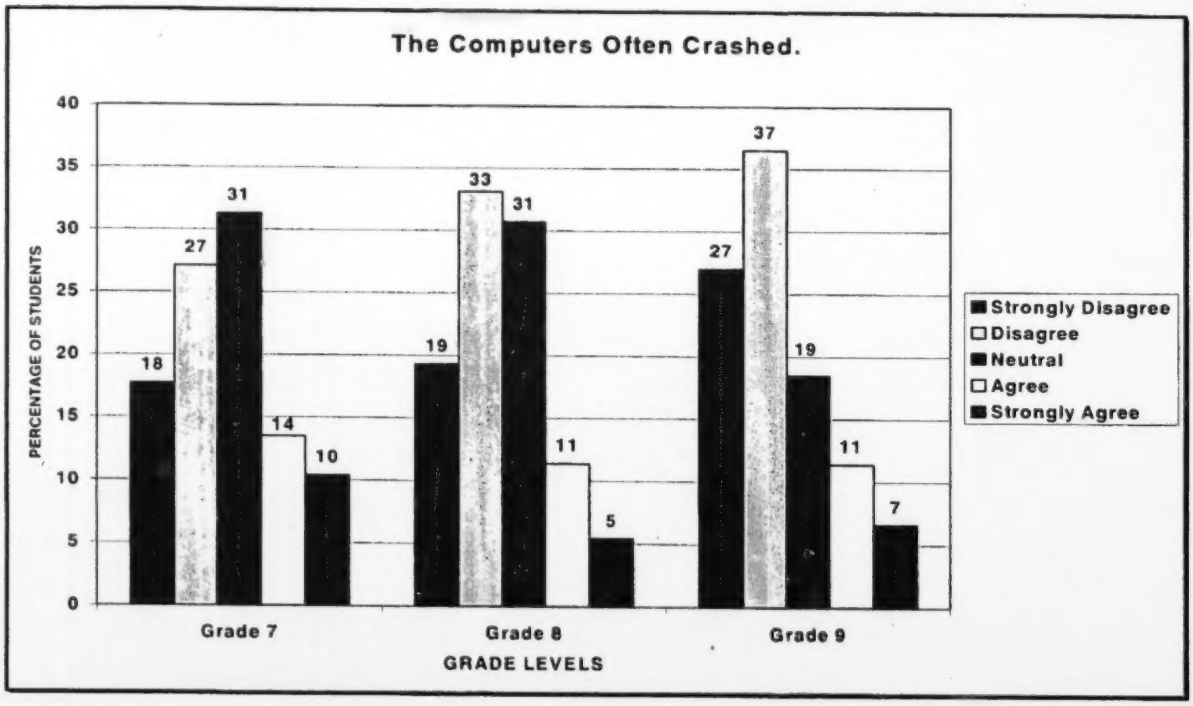
When asked if TLE made them feel comfortable around computers, the largest single response category was "neutral". This makes sense given the fact that most students already reported feeling comfortable around computers prior to using TLE. There were however, a greater percentage of grade 7 students (37%) expressing agreement with this statement.



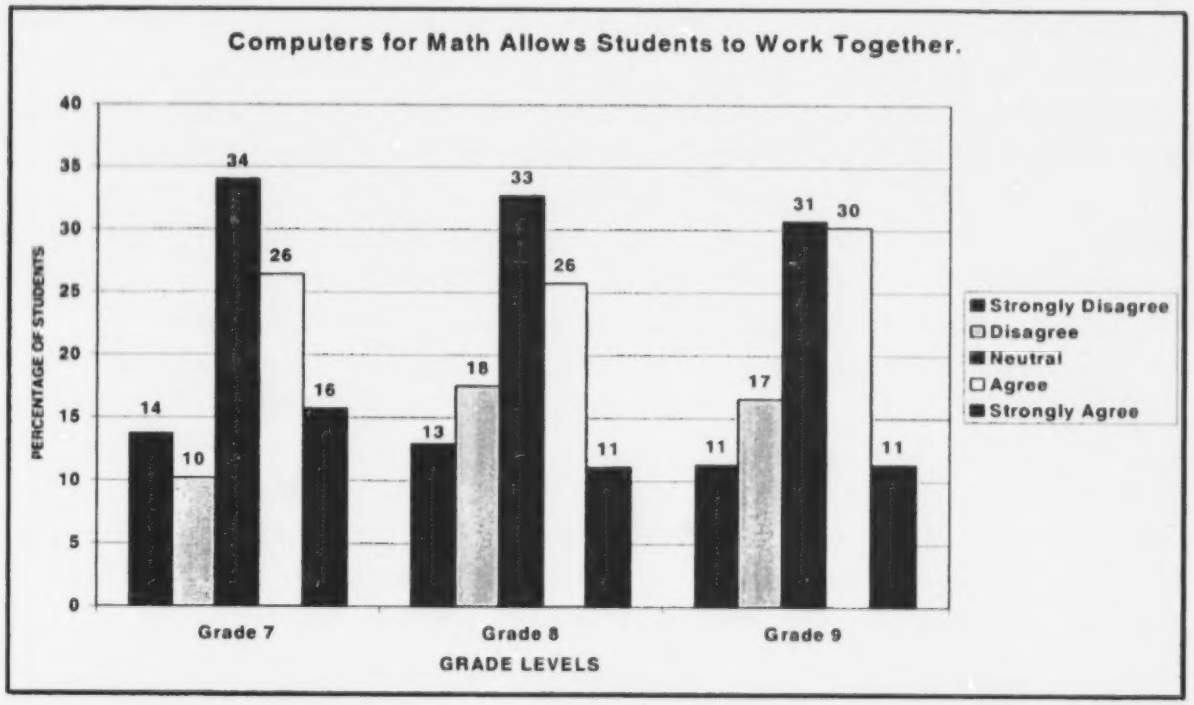
The survey also investigated students' perceptions of technical difficulties experienced in the TLE classroom. Almost half of the grade 7 students (46%) and approximately one third of the grade 8 (33%) and 9 (38%) students agreed with the statement that the computers they were using were too slow.



The majority of students had computers that were, at least, functioning much of the time. A small, but sizeable, proportion did, however, experience computer failure: Grade 7 students (24%) seemed to have a bit more difficulty with their computers than grade 8 and 9 students (i.e., 16% and 18% respectively).

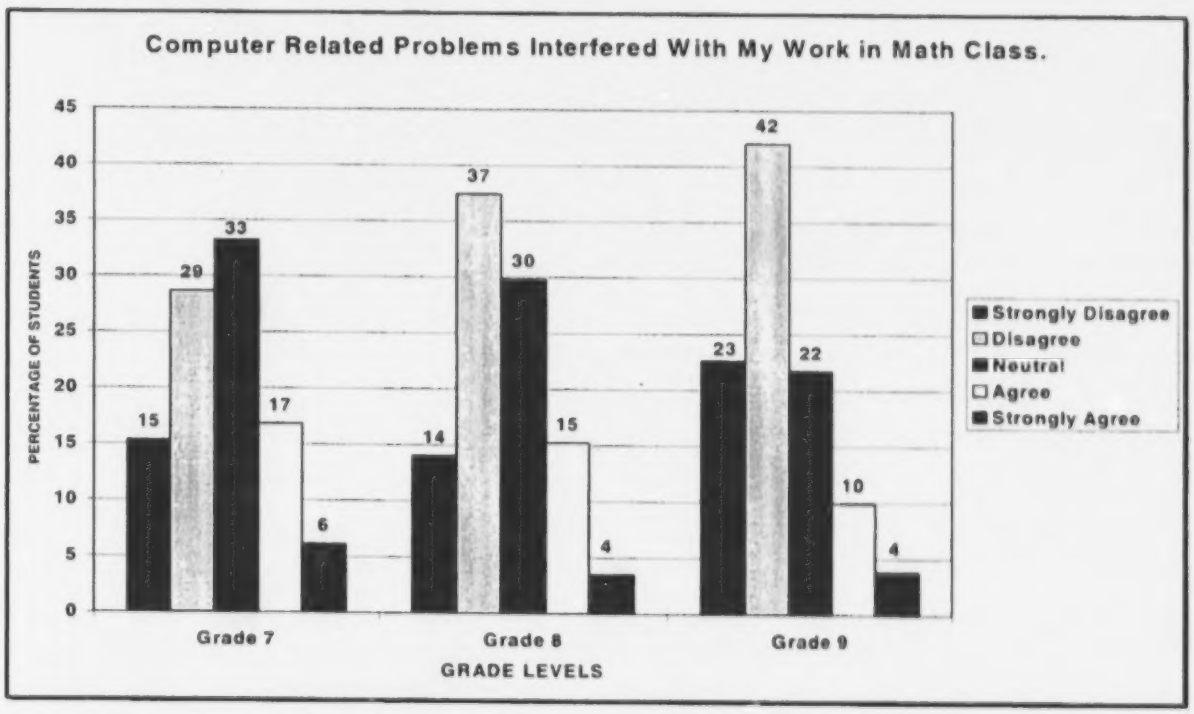


In order to explore the hypothesis that TLE may facilitate mathematics-focused student interaction, the survey asked students if they thought that TLE encouraged them to work together. Approximately one third of students expressed a feeling of neutrality on this issue. However, there was a slightly higher inclination towards agreement to this statement. Over one third of grade 7 (42%), grade 8 (37%), and grade 9 students (41%) agreed or strongly agreed that using computers in mathematics class facilitates their working together.



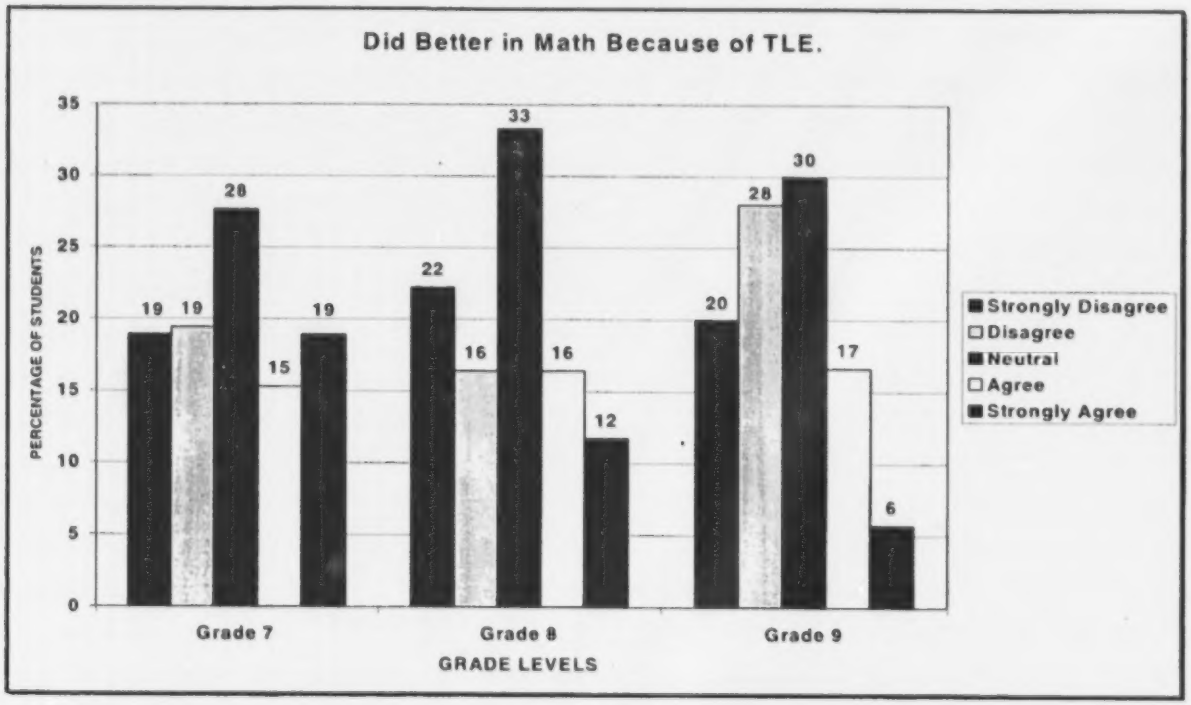
As noted above, computer related problems seems to be less of a problem as grade level increases. Less than one fifth of grade 9 students (14%) and grade 8 students (19%) agreed with the statement that computer related problems interfere with their work in mathematics class. A slightly higher proportion of grade 7 students (23%) agreed with this statement.

While the proportion of students who felt that computer related problems interfered with their work is not a majority of students, it is a significant proportion and does highlight the need for schools to ensure sufficient technical resources prior to implementing TLE.

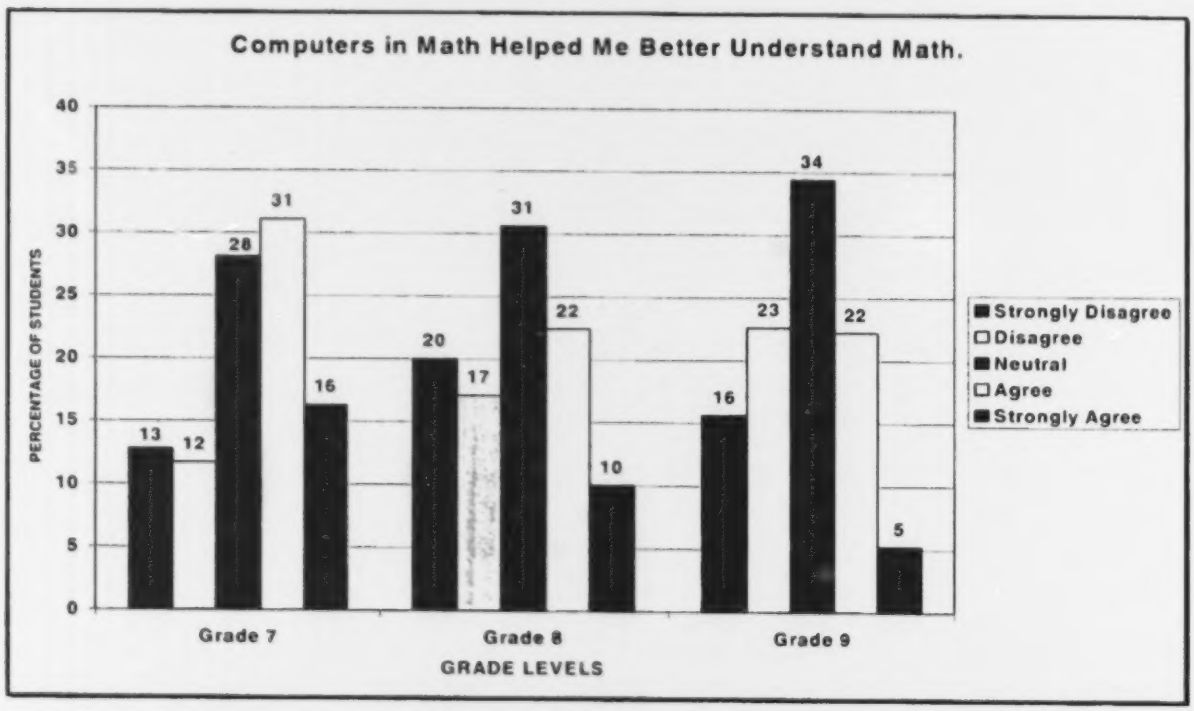


Mathematics and TLE

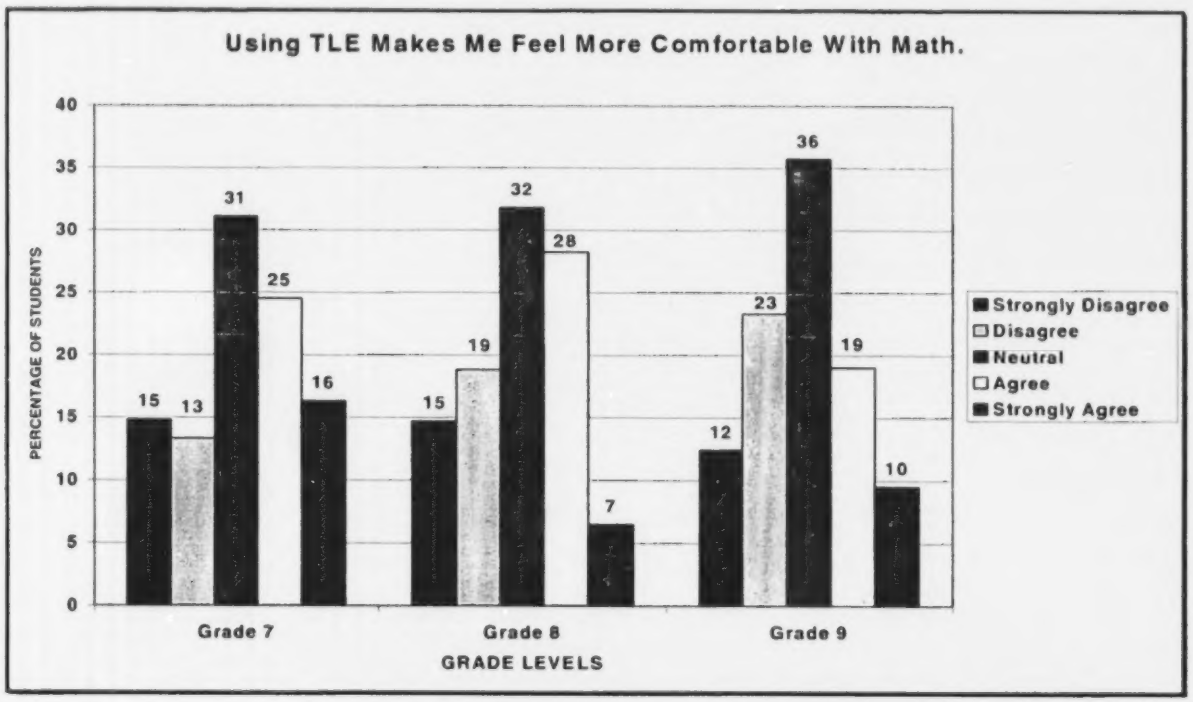
Student responses on the subject of TLE assisting with mathematics achievement were fairly evenly distributed amongst response categories. Although as mentioned above, grade 7 students seem to perceive more technical problems, their feelings about using TLE for learning mathematics seems more positive. Over one third of grade 7 students (34%) agreed that they did better in mathematics using TLE whereas, only 23% of grade 9 students agreed with this statement. Overall, most students did not agree that TLE contributed to their achievement.



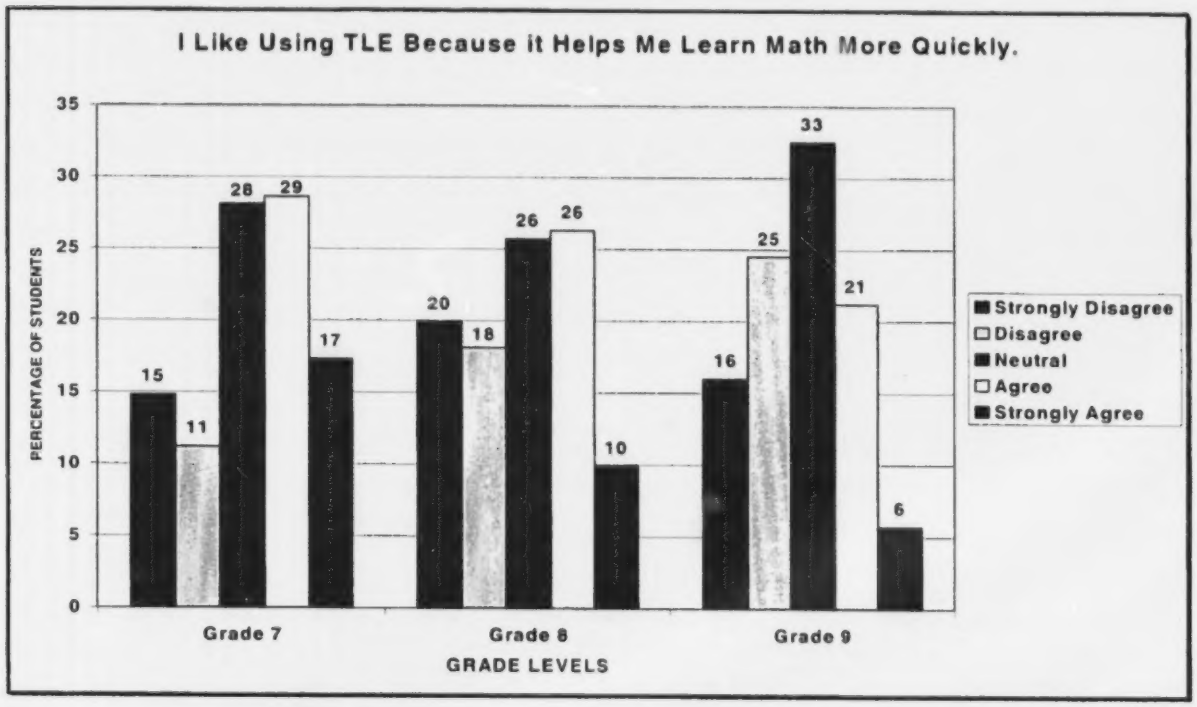
In terms of understanding mathematics, almost half of the grade 7 students (47%) agreed that using computers in class helped them better understand mathematics. Less than one third of grade 8 and grade 9 students (i.e., 32% and 27% respectively) agreed with this statement. Generally the responses were fairly evenly distributed amongst response categories.



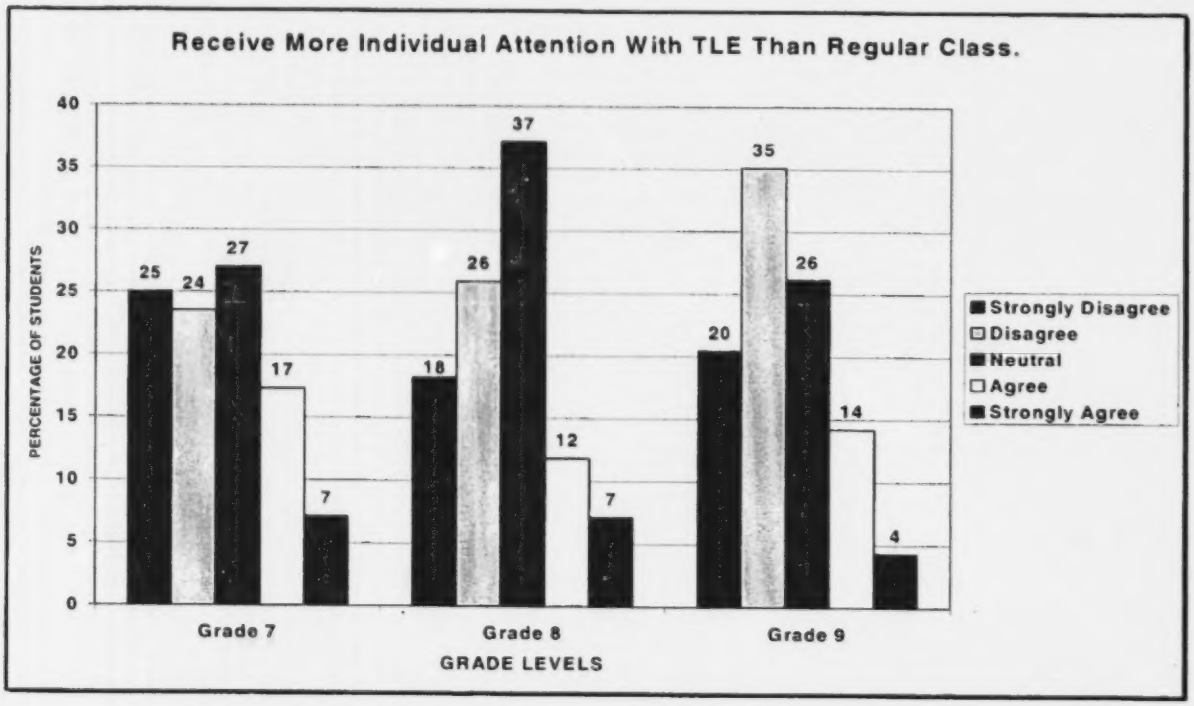
Students were fairly evenly split as to whether or not TLE made them feel more comfortable with mathematics. Again, there was a slightly greater proportion of grade 7 students (41%) agreeing that TLE made them more comfortable with mathematics.



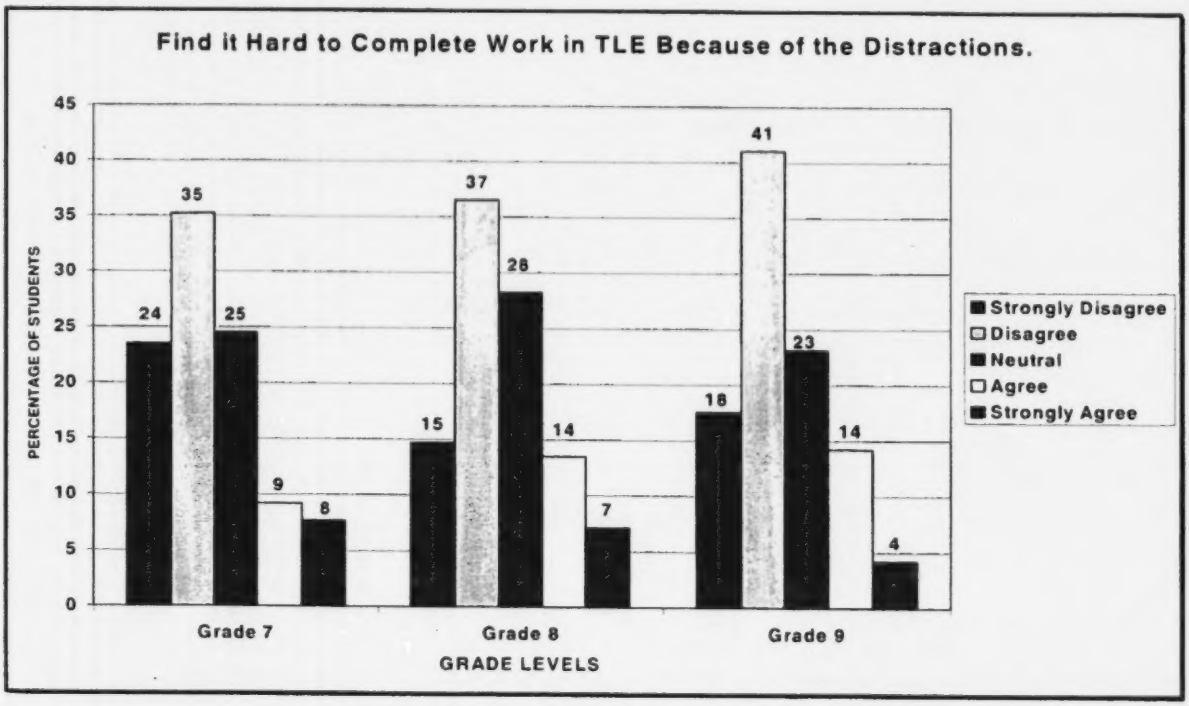
Almost half of grade7 students (46%) agreed they liked using TLE because it helped them learn mathematics more quickly. grade 8 students were evenly split - 36% agreed with the statement. Overall, grade 9 students seemed to be less impressed - 27% agreed with this statement.



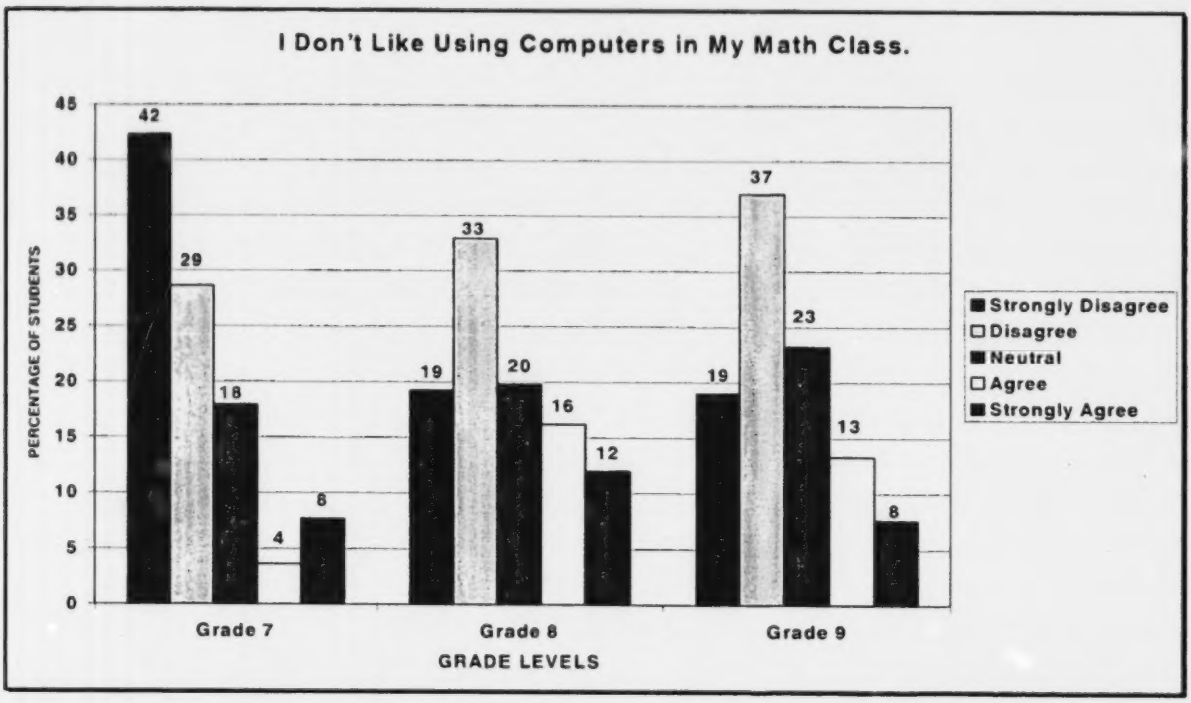
One generally hypothesized aspect of TLE is that it allows teachers to provide students with more individual attention in mathematics class. This was not, however, supported by students' perceptions. Over half of the grade 9 students (55%), 44% of the grade 8 students and 49% of grade 7 students disagreed that TLE facilitated more individual attention.



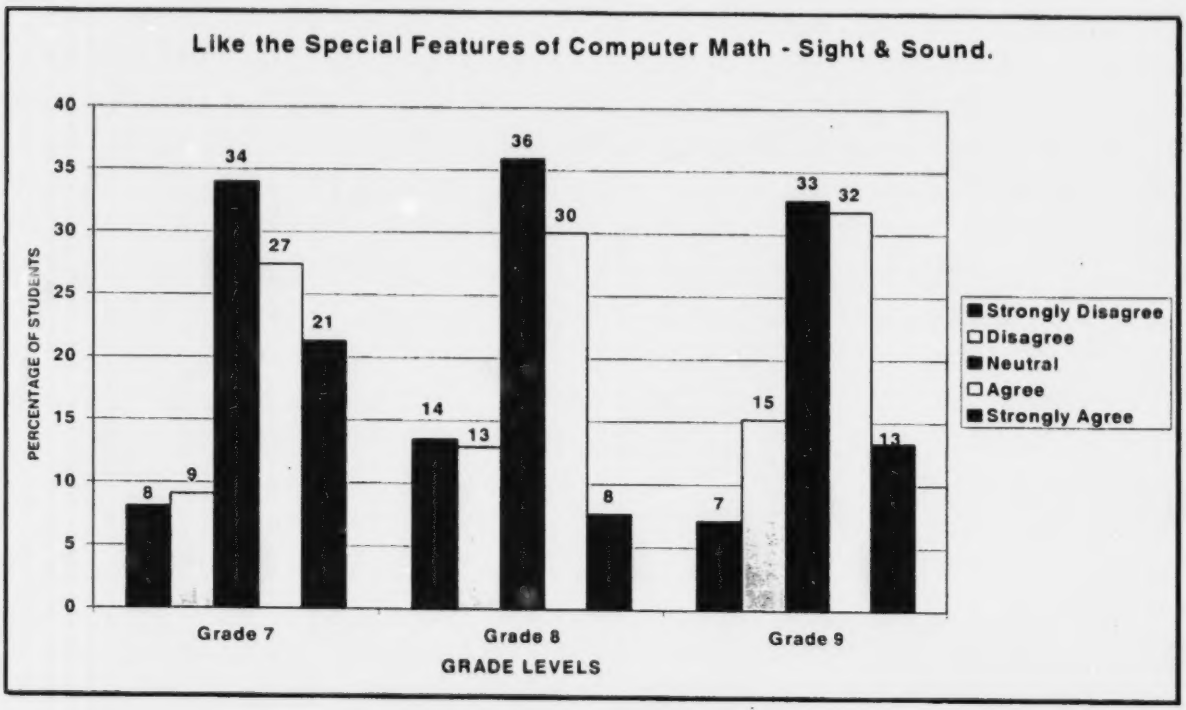
Overall, students did not find that the TLE classroom had distractions that would detract from their work. Fifty-nine percent of grade 7 students, 52% of grade 8 students and 59% of grade 9 students disagreed with the statement that TLE distracted them from their work.



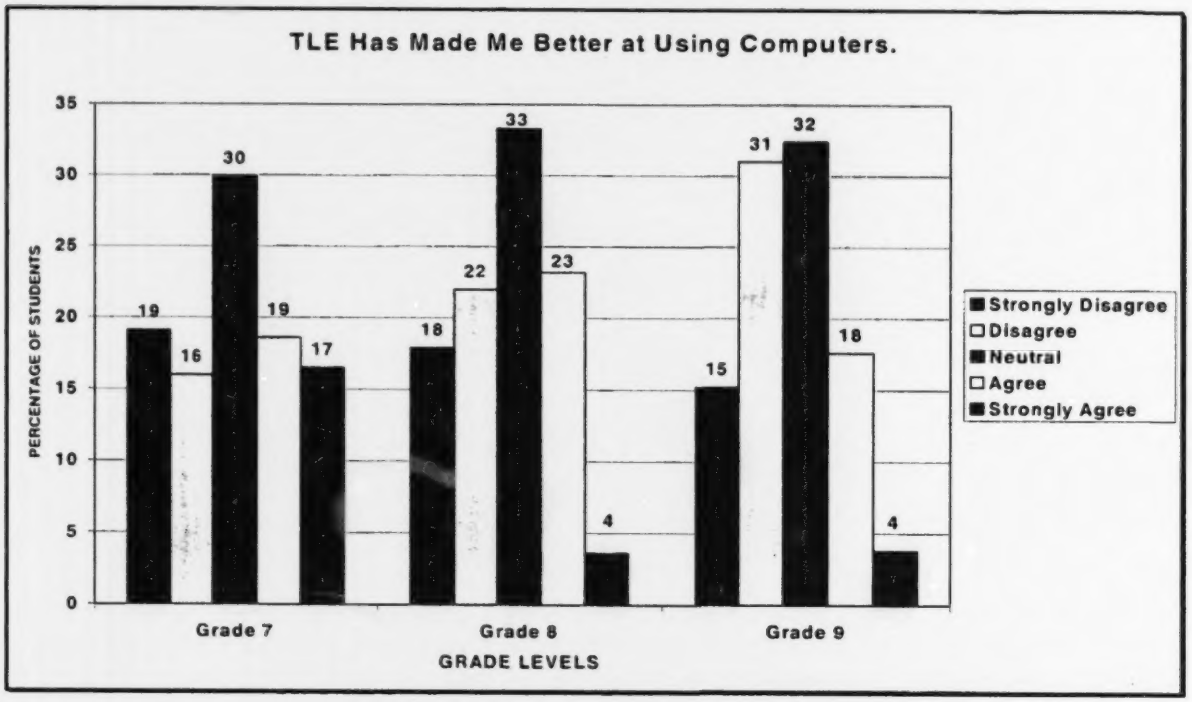
Over one half of the grade 8 and 9 students (i.e., 52% and 56% respectively) disagreed with the statement, "I don't like using computers in math class". The greatest level of disagreement (71%) with this statement came from the grade 7 students. In other words, most student like using computers in math class.



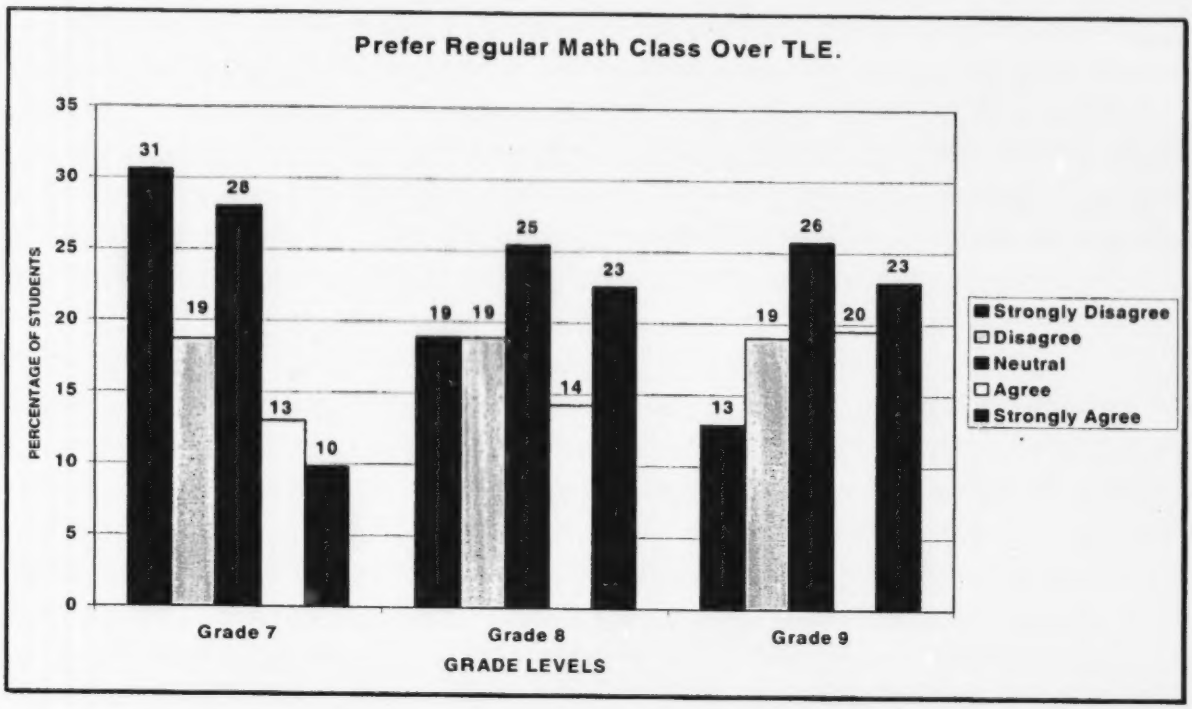
In general, students seemed to appreciate the visual and auditory features of TLE. Almost one half of grade 7 and 9 students (i.e., 48% and 45% respectively) liked these special features of the TLE program. Grade 8s were still positive, though slightly less so; 38% of grade 8 students liked the sight and sound that accompanies TLE.



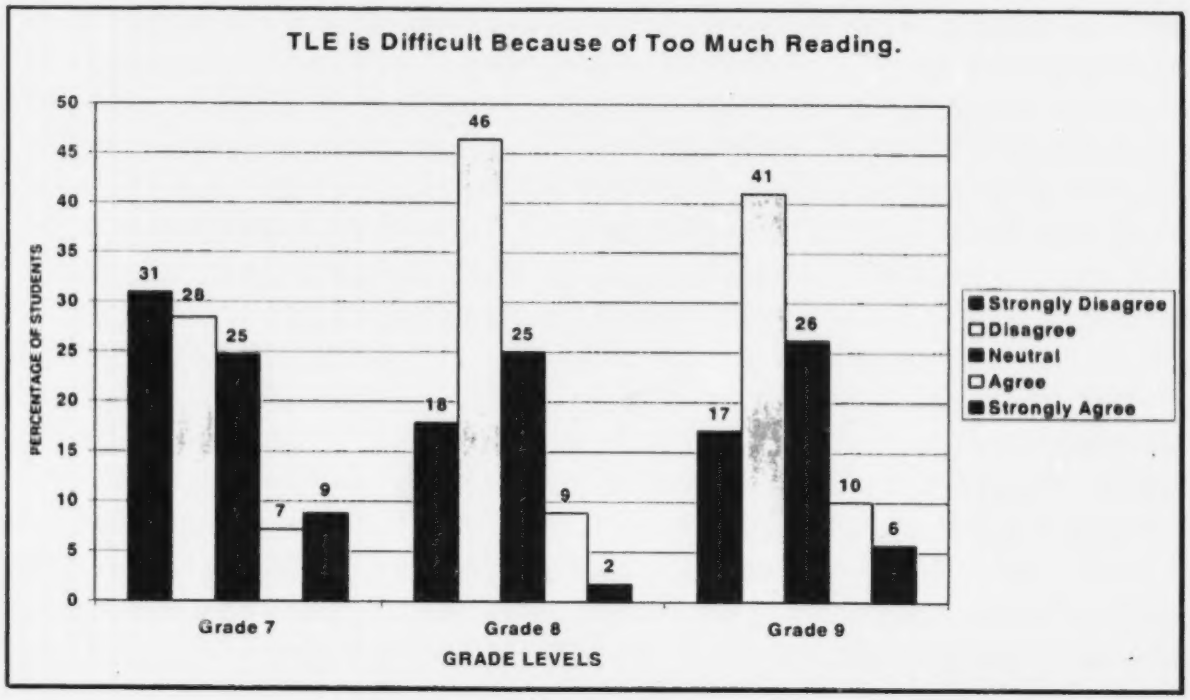
The proportion of students that feel TLE improved their computer skills decreases across the grades. Almost half of the grade 9 students (46%) disagreed that TLE made them better at using computers, whereas, Grade 7 and 8 student were evenly split between disagreement, agreement and neutrality with regard to this statement. This pattern may be due to the greater likelihood that older students had already experienced a significant amount of computer usage prior to beginning TLE.



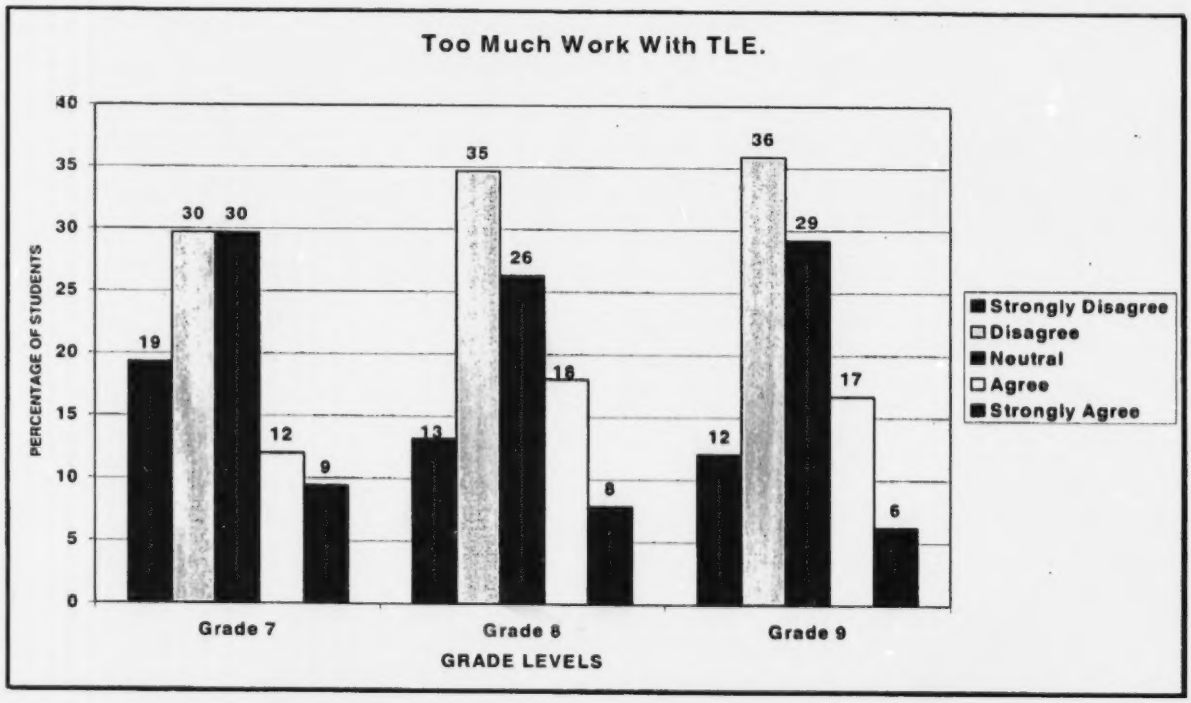
In terms of preferred method of instruction for mathematics, half of grade 7 students indicated a preference for TLE over regular mathematics classes. Conversely, 43% of grade 9 students indicated they prefer regular math class to TLE. Grade 8 students were fairly evenly divided in their preferences for TLE or regular mathematics class.



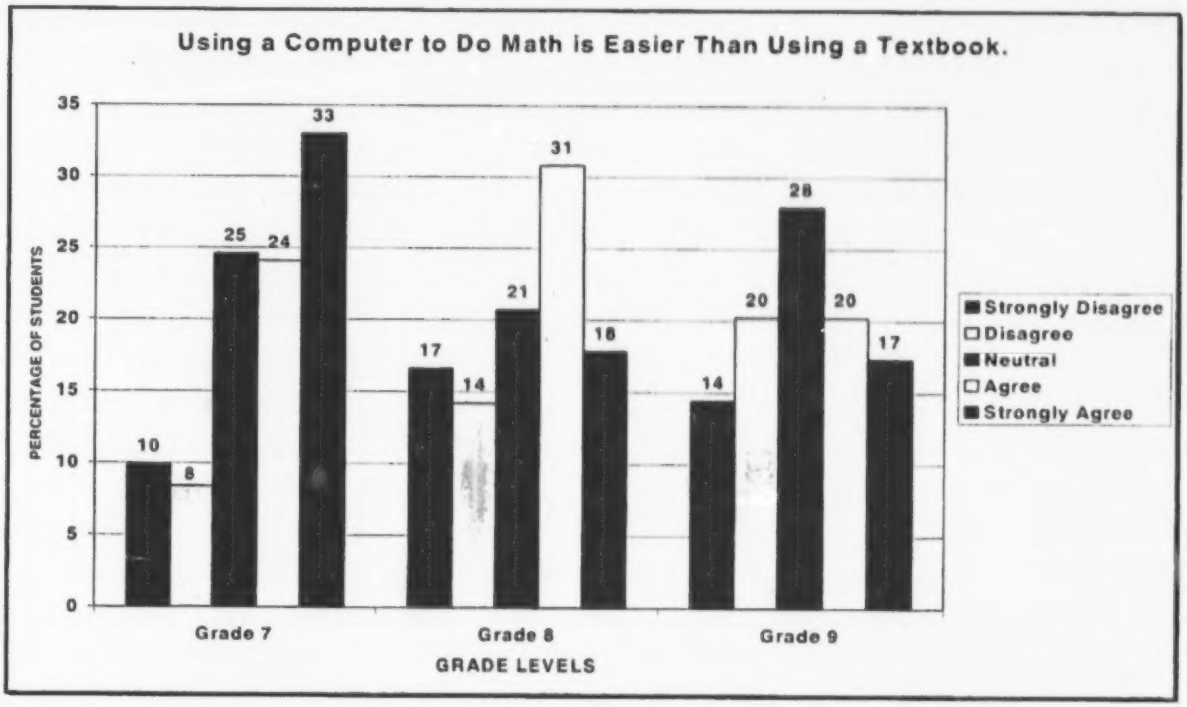
Only a small proportion of students – 16% in grades 7 and 9 and 11% in Grade 8 - thought that the amount of reading required by TLE made the program difficult. This may, however, be an important subset requiring additional attention from the teacher.



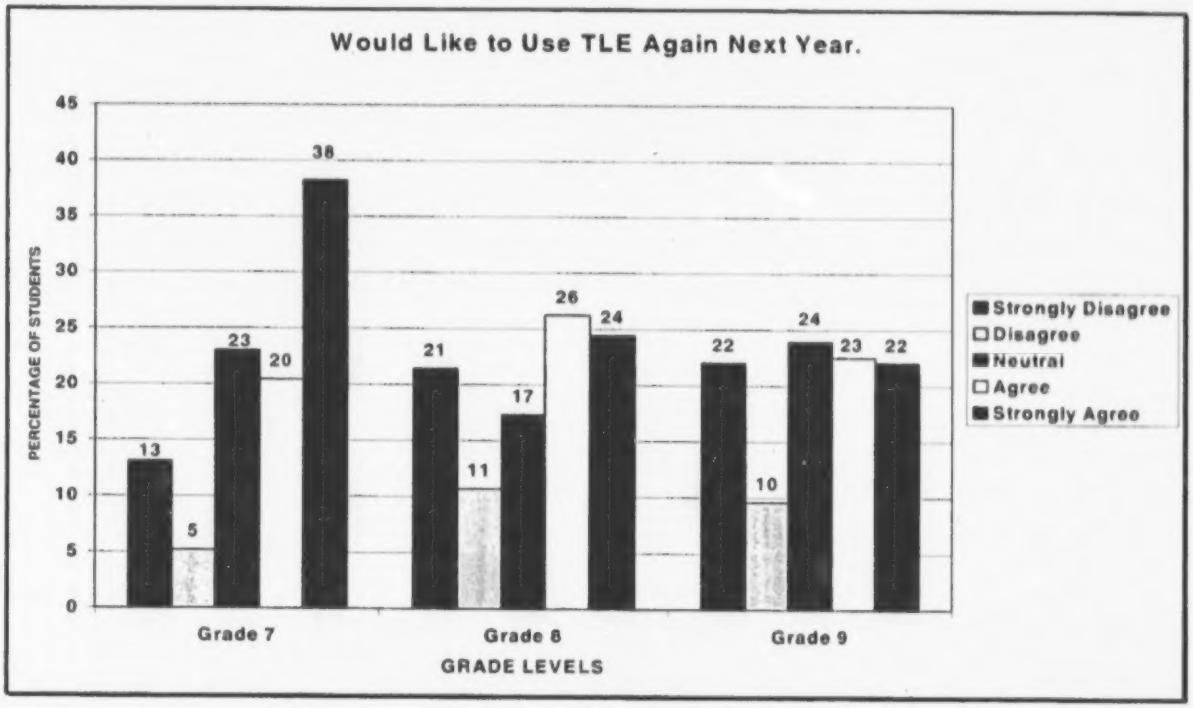
The majority of students did not feel that TLE was too much work. Almost half of all grade 7, 8, and 9 students disagreed with the statement that TLE was too much work (i.e., 49%, 48%, and 48% respectively).



When asked to compare the difficulty level of TLE to a textbook, a somewhat higher proportion of students thought TLE was easier. Over one half of the grade 7 students (57%), almost half of the grade 8s (49%) and over a third of grade 9 students (37%) agree that it is easier to do math using a computer. It should be noted however, that 31% of grade 8s and 34% of grade 9 students disagreed with this statement.



Approximately one half of students in grades 8 (50%) and 9 (45%) would like to use TLE again next year. Grade 7 students were a little more enthusiastic, 58% agreed that they would like to use TLE again. There were also significant proportions of students that disagreed with this statement and would not like to use TLE next year. Almost a third of grade 7, 8, and 9 students disagreed with this statement (18%, 32%, and 32% respectively).



Length of Exposure to TLE

The observations of TLE students were further analyzed according to their level of exposure to TLE. In order to determine the effects of lesser and greater exposure of TLE on student attitudes, the students were categorized into 2 groups. The first group – "Less TLE" - includes those students attending less than 3 classes of TLE per week (n = 200). The second group – "More TLE" - includes those students attending 3 or more classes of TLE per week (n = 360).

Independent sample t-tests were conducted to determine if the amount of exposure students had to TLE related to their attitudes about mathematics, computers and TLE, itself. These comparisons were calculated by grade, by gender, and overall effect[11].

Overall, students in the higher exposure TLE group had more positive attitudes about computers, mathematics and using TLE. Since attitudes were measured on a 5-point scale where a higher score reflects more agreement with the statement, "Higher Agreement" in the table indicates significantly more agreement with the corresponding statement. Please note when interpreting the table that there are both negative and positive statements.

Students attending 3 or more TLE classes per week had significantly higher levels of agreement with positive statements regarding the use of computers and TLE for mathematics, than students attending less than 3 classes per week. In addition, students in the high TLE category were less likely to agree with negative statements such as, I like regular math lessons more than TLE. Although students exposed to more TLE seem very positive in terms of preferring TLE, these students do consider TLE more work.

Opinion Differences by Length of Exposure to TLE		
Computers	**MORE TLE**	**LESS TLE**
Using TLE makes me feel more comfortable around computers.	**HIGHER Agreement**	LOWER Agreement
Using TLE has made me better at using computers.	**HIGHER Agreement**	LOWER Agreement
Using a computer to do math is easier than using a textbook.	**HIGHER Agreement**	LOWER Agreement
Mathematics		
I like using TLE because it helps me to learn math more quickly.	**HIGHER Agreement**	LOWER Agreement
I did better in math this year because of TLE.	**HIGHER Agreement**	LOWER Agreement
Using TLE makes me feel more comfortable with math.	**HIGHER Agreement**	LOWER Agreement
I receive more individual attention from the teacher during TLE math than I did in regular math class.	**HIGHER Agreement**	LOWER Agreement
I like regular math lessons more than TLE.	LOWER Agreement	**HIGHER Agreement**
There is too much work to do in TLE.	**HIGHER Agreement**	LOWER Agreement

[11] All entries in tables are statistically significant to $p < 0.05$

The amount of time spent using TLE seems to have a greater impact on the attitudes of female students, than on male students. Female students using TLE more frequently were significantly more likely to agree that they gained comfort around computers, use them more efficiently, and, most importantly, are more likely to prefer using computers for mathematics.

Female students exposed to more TLE were more likely to feel that they did better in mathematics and understood mathematics better using TLE. Moreover, this group of female students was more likely to agree that they found it easier to using a computer to do mathematics than using a textbook.

Opinion Differences by Length of Exposure to TLE and Gender				
	Male		Female	
Computers	**MORE TLE**	**LESS TLE**	**MORE TLE**	**LESS TLE**
Using TLE makes me feel more comfortable around computers.			**HIGHER Agreement**	LOWER Agreement
Using TLE has made me better at using computers.			**HIGHER Agreement**	LOWER Agreement
Using computers in math has helped me better understand math.			**HIGHER Agreement**	LOWER Agreement
I did better in math this year because of TLE.			**HIGHER Agreement**	LOWER Agreement
Using a computer to do math is easier than using a textbook.			**HIGHER Agreement**	LOWER Agreement
Mathematics				
I like using TLE because it helps me to learn math more quickly.			**HIGHER Agreement**	LOWER Agreement
I receive more individual attention from the teacher during TLE math than I did in regular math class.	**HIGHER Agreement**	LOWER Agreement	**HIGHER Agreement**	LOWER Agreement
I like the special features of computer math lessons, such as color and sound.	LOWER Agreement	**HIGHER Agreement**		
I like regular math class more than TLE.			LOWER Agreement	**HIGHER Agreement**
There is too much work to do in TLE.			**HIGHER Agreement**	LOWER Agreement

Summary: Length of Exposure to TLE

It appears that the amount of time a student is exposed to TLE has a positive effect on a student's attitudes regarding both mathematics and computers. Moreover, students with high exposure to TLE are significantly more likely to prefer TLE to regular mathematics class.

Teacher Focus Group Analysis

INTRODUCTION

Overall, 29 junior high teachers participated in three TLE focus groups conducted by Alberta Learning from December 1 through 7, 2000. In general, focus group participants used the TLE program for mathematics instruction for approximately 2 to 3 years. The majority of focus group participants had generally positive experiences with TLE. Focus group participants implemented TLE in their mathematics lessons in a variety of ways, ranging from using the program as a primary

resource for mathematics delivery to using it as a supplementary resource blended with traditional methods of teaching mathematics.

The following topics formed the basis for focus group discussion:

- Reasons for using TLE
- Supports needed
- Changes in the Classroom: Teacher's Experiences
- Changes in the Classroom: Effects on Students
- For which groups of students does TLE work the best?
- Successful TLE practices
- Issues with implementing TLE
- Teachers' personal gains resulting from using TLE
- Closing comments about TLE

The listed topics were used only as a general guide to ensure that all questions the research team was interested in were addressed. Therefore, as expected, the discussion turned in some cases into a spontaneous exchange of ideas and opinions among the teachers and did not follow exactly the structure of our preliminary topics. Some topics overlapped, some of them turned out to be more important to the teachers than we initially thought they would be, and some issues proved to be of less importance. In addition, some new, unexpected issues arose in the course of the group interviews.

The following sections outline major themes that emerged as a result of the focus group discussions.

1. REASONS FOR USING TLE

The majority of focus group participants began using TLE in hope that this new approach to mathematics delivery might contribute positively to mathematics achievement. The second appealing factor was an opportunity to introduce technology in the classroom for the benefit of both the students and the teacher. The third reason, which is closely related to the two preceding ones, was an opportunity of trying a completely new teaching strategy, which would introduce more *flexibility* into a mathematics class compared to the traditional mathematics class. Lastly, support from colleagues and administration seemed to play an important role in the teachers' decisions to use TLE.

Student Achievement

According to the majority of focus group participants, an opportunity to *increase student achievement* was a key driving force behind their decision to try the new teaching methods and technologies incorporated in TLE. As one of the teachers put it, "an ultimate goal is increasing students' achievement." Many of the teachers reported that, in their opinions, TLE does contribute to increased student achievement.

New Technology in the Classroom

Some of the teachers mentioned that using TLE provided them with a chance to introduce new technology into the classroom. As one of them put it: "Why not be on the leading edge of technology instead of catching up with it?" Exposing students to computers is one of the major

ways of enhancing their technological literacy. This is especially true for students who do not have opportunities to attain computer skills outside of school. Using TLE allows teachers to combine innovative teaching strategies while developing technological competence in students.

Furthermore, some of the teachers thought that introducing technology in their classrooms might help them to motivate students. As noted by one of the teachers, "kids seem to be attracted to computers."

Innovative Instruction

Many participants felt that using TLE was a unique opportunity for both themselves and their students to learn something completely new. In particular, teachers thought that students' attention could be caught by TLE. Teachers commented on this matter as follows:

- "TLE gives the kids another avenue... Kids are bored sometimes, and TLE gives them motivation."
- "I would like to give my kids something more interesting, and Grade 9 Mathematics is not very interesting. (I want) to bring some excitement to the classroom."
- "They (students) come from other (regular) classes where they were lectured to, were listening." Therefore, coming after that to a TLE class is a refreshing experience for them. They start to do something different, switch to a new, fresh mode of learning, get a nice change from routine."

Teachers also turned to TLE as a method of addressing the diversified learning needs of their students. The vast majority of the focus groups participants taught heterogeneous classes with some of the students being top achievers, others being somewhere in the middle, and some kids achieving at a below-average level. According to the teachers, it is difficult to teach such diverse groups of students in a traditional manner with a teacher lecturing to the whole class. TLE facilitates small group or one-on-one instruction and hence, allows a teacher to reach students working at a variety of levels.

TLE also offers the ability to individualize instruction by having students on different lessons. One of the teachers addressed the issue of very high (48%) turnover in his school by using the TLE program, which "allows them (students) to learn fast and catch-up quickly. That's a big change from traditional learning."

An interesting reason for using TLE came from a young teacher who started using the program as a "back-up" for her own teaching, because she was not sure if all of her students understood her explanations. She felt that TLE offers another, complimentary, approach to explaining mathematics. Unlike a traditional classroom where students only hear one perspective, this offers teachers the opportunity to present multiple perspectives.

Encouragement from Colleagues and Administration

Some focus group participants noted that inspiration and support on the part of their colleagues played a role in their decision to start teaching with TLE. For example, a number of the teachers mentioned positive effects of Eddie Mah's – an early user of TLE - presentations about TLE. His enthusiasm and faith in the program convinced them to give it a try. In some instances other mathematics teachers in the school were interested in using TLE or had a positive experience with the program. Lastly, school and district administrators sometimes played an instrumental role in convincing teachers to use TLE.

In a few cases, teachers were directed to use TLE by the school administration. This seemed to increase the chances of having a negative TLE experience. While some of the teachers "bought into" their administration's initiative and believed that switching to TLE was the best alternative for teaching mathematics, a number of their counterparts expressed a more cautious attitude towards "one-person" administrative decisions. One participant related the experience at his school where a colleague was pushed into TLE by the school principal. The students immediately sensed lack of enthusiasm on the part of the teacher, and the class did not go well.

Rating Reasons for Using TLE

At the end of this discussion topic, the participants were asked to prioritize their responses on the opening question about reasons for using TLE. Overall 4 to 5 major reasons (refer to the following table) for using TLE emerged within each of the groups. Table 2 makes it possible to compare the responses of individual groups. However, one should keep in mind that the teachers reverted to the reasons behind using TLE on many occasions throughout the consultations. Therefore, the responses outlined here reflect only "first thoughts," which underwent further development and clarification in the course of subsequent discussions.

Rating of Reasons for Using TLE

Rank	Focus Group # 1	Focus Group # 2	Focus Group # 3
1	Improve student achievement	Improve student achievement	Teach students at differing levels
2	Encourage active learning	Implementing technology in classroom	Improve achievement through the use of technology
3	TLE offers (students) material for independent study	• Try another instructional delivery strategy • Supplement to existing instructional materials • Other teachers' positive TLE experiences • Students are attracted to technology (enhances student motivation) • Support different learning styles	• Try another instructional delivery strategy • Supplement to existing instructional materials • Administrative encouragement to use TLE • Very diverse group of students; difficult to teach them in a traditional manner
4	Exposure of teachers and students to new technology	Administrative and/or collegial encouragement/directive	Administrative and/or collegial encouragement/directive
5	• Motivate students • To better prepare students for high school • To individualize instruction	Collegial encouragement to use TLE	None

2. SUPPORTS NEEDED

The issue of supports needed was one of the most extensive and multi-faceted themes that emerged in the focus groups. It came up during discussion of virtually each and every topic and closely intertwined with other aspects of using TLE.

The consultations revealed that an adequate technical infrastructure is absolutely necessary for implementing TLE. As one participant noted, "There was great enthusiasm in the beginning. But without a support mechanism the usage (of TLE) dropped." Collegial and administrative supports

were also seen as a crucial and related to the issue of technological infrastructure as one of the major outcomes of administrative support is ensuring that the necessary technology is in place. Lastly, the focus group participants thought that support from the software provider, including the key component of receiving in-service prior to implementing TLE was necessary for successful TLE implementation.

Technical and Financial Support

Focus group participants agreed that availability of adequate financial and technical supports is a key condition ("a huge issue") for successful teaching with TLE. The teachers reiterated on several occasions that having the necessary means prior to launching the program would help avoid problems.

When discussing technical issues, the teachers stressed the importance of having accessible, properly spaced, and conveniently organized lab facilities. According to the teachers, lab facilities can be a very big issue. For example, one of the teachers reported that his school does not "have any decent size rooms to establish a computer lab." His colleague mentioned having one computer lab for 700 people. Using "someone else's lab," competing with other teachers for lab time and moving students from one room to another can be very frustrating. According to the teachers, space greatly impacts their ability to manage the class. "Sometimes kids share 48-inch spaces, (they) are very packed." In a well-spaced lab students have sufficient space so there is less touching and fewer discipline violations.

As expected, availability and capacity of computers were mentioned as an important technical issue. One of the teachers told the group that the demand for TLE-based mathematics in her school is not being met due to the lack of computers. Not all students who wish to take the program are able to enter the TLE class because of limited availability of computers. Another teacher complained about the inadequate capacity of computers: "In my class computers are freezing/dying every day." This upsets and disrupts students. According to the teachers, servers with extra memory are very effective and make it possible to avoid these technical interruptions.

The presence of technical support personnel was also mentioned as necessary to ensure TLE runs smoothly. Although some of the teachers thought that TLE "is not a hard program to learn," because of its technical nature, one does need to troubleshoot technical problems; obviously not everyone is able to "become a tech guy" so having that technical support available becomes necessary. "You need a person who definitely knows computer systems and networks, not only TLE."

Administrative and Collegial Support

There was agreement across all groups on the importance of administrative support because "you need a lot of resources" to implement TLE, though concentration on this domain varied among the focus groups. There were positive comments on this issue, including statements such as: "Administration went for it, encourages a focus on technology." However, there were also many concerns about inadequate support on the part of school administration. Statements such as: "We are *fighting* the administration" attest to a lot of frustration experienced by some of the teachers about this issue.

Those focus group participants who experienced a lack of administrative support often attributed this problem to insufficient knowledge on the part of school administrators about TLE and the benefits resulting from this alternative method of mathematics delivery. Therefore, according to the teachers, obtaining and disseminating relevant TLE information among school administrators and superintendents ("educating them") is crucial in "accelerating access to TLE and making it a success. As one of the participants commented: "We need to advertise good stuff and get support from administration and colleagues!"

An important part of this strategy is showing administrators "hard evidence" that using TLE is indeed beneficial, including data on improvements in student achievement (trend data for 3 years would be useful). According to one of the teachers, the "administration wants everything in writing: that's what we have, and these are the results."

In addition to administrative support, collegial support was also seen as key. The focus group discussion evolved around two major types of collegial support, namely, communication with other TLE users and support from high school teachers.

With regard to the support from colleagues who had been using TLE, the teachers mentioned that it is especially needed for the beginners who may not be comfortable with the program for some time. "It is nice to talk to people in the same area, find what is working (and) what is not." However, collegial communication is also important for "established" TLE users - "to see what's happening, what's counting". The need for the TLE community to become well informed and consolidated was clearly discernible during the focus groups. It was apparent that a "round table" discussion setting was a great opportunity for the teachers to do some networking and communicate ideas and information.

The focus groups revealed that approval from *high school teachers* might be an important factor in administrative decisions regarding using TLE. At the same time the focus groups consistently reported lack of support from high school teachers. According to the participating teachers, "people in high school" often do not see the benefits of TLE. As discussed earlier, this can be explained by a lack of knowledge of the program and its advantages on the part of high school teachers and administrators.

Parents were another group that participants thought were an important source of support (or lack thereof). The teachers reported that "parents are not always convinced that TLE is a good way to go" and that "some parents very vocally oppose TLE...instead of being excited about using new technology and computers." The teachers believe that, similar to administrative support issues, these problems originate in the lack of communication with the parents who often are not well informed about the TLE program.

The student support component of teaching TLE usually was not directly articulated during the consultations. The key point mentioned by the teachers was the ability or/and willingness of students to assume responsibility for the learning process. This attribute may depend on students themselves - their overall motivation, maturity and abilities including reading skills - or be stimulated by a teacher. There were many positive remarks with regard to high student motivation in TLE classes.

At the same time, the participants admitted, "some kids are not responsible for their learning at all." In addition, there is always a limited number of students who don't like using computers and "some kids just prefer a textbook, even high-end kids."

Support from the Software Provider (Nelson)

It followed from the consultations that the teachers would like to maintain a close, continuous relationship with the software developer. Currently the two parties seem lacking a steady, two-way contact. As one of the teachers put it, "Initial teacher support (by Nelson) is very good. But what about someone talking to you after you started using it (TLE)?"

Many of the teachers emphasized the importance of having sufficient supplementary resources for delivering TLE mathematics (journals, spreadsheets, etc.) and a current shortage of these resources. Missing resources include test banks designed specifically for TLE, worksheets modified for kids at high, average and below-average levels in mathematics, and easier refreshers. According to the teachers, this type of support is especially vital for the initial stages of introducing TLE.

The teachers mentioned that they would like "communications of the changes in the program" and other current information from Nelson including information about in-service. One participating teacher had never even heard that there was TLE in-service available, and she was amazed that others had these services. Presently the communication between teachers and the software developer is hampered by the lack of a tracking system of active TLE users (teachers and/or schools.)

3. CHANGES IN THE CLASSROOM: TEACHERS' EXPERIENCES

Based on the teachers' accounts of their classroom experiences, one can conclude that using TLE changed the whole process of teacher-student interaction. First, each TLE student works independently and at his/her own pace at the computer. Second, it becomes easier for a teacher to monitor the progress of individual students. According to the focus group participants, with TLE "we see if they (students) understand, whereas when they read a textbook, we don't know if they understand from paragraph to paragraph." Third, a teacher becomes more available to students and has better contact with them. Students get a chance to come back to the teacher with questions and receive immediate feedback. All of these TLE-related features make it possible to support *active learning* in the mathematics classroom versus passive, lecture-based learning that prevails in a traditional mathematics class.

As a result of their new facilitating roles and also due to the flexibility of TLE, teachers have more room for creativity in the TLE classroom than in a traditional mathematics class. TLE-based teaching can incorporate both new, computer-based teaching and elements of traditional approaches to teaching mathematics. This broader pool of available teaching strategies makes it possible for teachers to experiment to find approaches that are most suitable for their students.

Increased responsibility of students for their own learning, individualized approach to teaching, increased teacher availability, and an opportunity for a teacher to constantly modify and adjust teaching techniques, makes TLE-based learning an *active* and dynamic process - both teachers and students are active participants in this process. As focus group participants observed, TLE provides "active learning and a more effective way of teaching."

Teachers as Facilitators

Teaching using TLE drastically changes a teacher's role from that of a "lecturer" and sole information source to a facilitator of learning. The student becomes a central figure in the learning process with the teacher acting "from aside," detecting students' needs, providing necessary feedback and assisting them in carrying out their individual learning. Put another way, in a TLE-based class a teacher directs students rather than controlling classroom activities.

The TLE classroom is less structured and not teacher-driven. A teacher does not necessarily lecture before the entire class and each student has access to his or her own teaching source - a computer with the TLE program. Under these circumstances students are able to work at their own pace and a teacher can provide additional individual assistance to students. Often instruction is done in small groups. Thus, the role of the teacher changes drastically in a TLE class. As focus group participants pointed out, the teacher is "a *facilitator, a troubleshooter*," "the focus is on students, not on the teacher." As a result, according to the teachers, "in the computer lab you immediately adapt to them (students) unlike (teaching with) the textbook, where everyone in the classroom has to do the same thing. (This is) definitely an advantage."

Flexible Teaching and Learning

The general theme that underlies the teachers' accounts of their experiences using TLE and their changing classroom roles is attaining great *flexibility* in all aspects of teaching activities. This increased flexibility includes both methods of mathematics delivery and communication with the students. Participants in different focus groups repeatedly and explicitly articulated the flexibility point including statements such as:

- "TLE makes you more flexible in your teaching."
- "(TLE) makes the learning environment more flexible."
- "TLE gives extreme flexibility in problem solving."
- "(TLE) makes teachers more flexible."

The possibility of blending TLE in different ways with traditional methods of mathematics delivery is one aspect of its flexibility. This flexibility and variety of resulting strategies makes TLE a great tool for reaching as many students as possible because it helps teachers to adjust to each child's learning style and thereby *individualize* the teaching and learning process. "TLE is good as a supplement for kids who have difficulties with the usual ways of mathematics delivery." TLE provides an opportunity to go through the topic in a different way and thereby makes it possible for a teacher to "re-teach" material to children who are not comfortable with traditional ways of learning.

Accessibility of the Teacher

An essential aspect of teaching with TLE is the teacher's increased *availability* to the students. "Kids use computers, then they come back to the teacher with questions." The enhanced ability of the teacher to detect problems and provide immediate feedback to the students is an important implication of the increased teacher's availability. "One of the big changes (from a traditional classroom) is feedback." According to the teachers, in an active TLE-driven environment they "see if students understand," which would be difficult if students simply read a textbook. Also, an "unfocused kid is immediately recognized by the teacher."

Creative Instruction

As mentioned earlier, TLE is a very flexible teaching tool, which can be used as a primary resource, as a supplement in a variety of blends, and for independent studies such as virtual learning. This unique quality of TLE along with a changed role of the teacher to being a facilitator rather than a sole deliverer of material makes it possible for mathematics teachers to experiment with teaching approaches and express a high degree of creativity. The increased room for creativity has important implications for both teachers and their students. First, teachers are able to better adjust their teaching methods to the needs of the students. According to one of the teachers, "Some lessons can be skipped, some can be an enrichment thing and not be done with the whole class." Second, teachers get a chance of experimenting, learning and perfecting their teaching.

Increased Workload

Almost all of the teachers pointed out that their workload increased substantially as a result of incorporating TLE in their teaching practices. The teachers unanimously agreed that, contrary to a possible "common" perception that with a computer there is not much work left for a teacher, there is preparation involved in teaching TLE. The teachers provided the following specific examples of increased work:

- "Some people probably think that you are doing nothing. But I still teach as a 'second teacher.' I have much more marking (different type of marking.) Children have handouts every lesson. Journals, student refresher assignments…there is a lot to look at."
- "(There is) lots of marking to be sure that students are achieving something."
- (This teacher uses TLE 100% of time.) "It is still half me, half the computer. I first explain things, show the examples, then they go to the computer. You can't just say: 'Go and do it.'"
- "We keep the lab open every day after school. Sometimes I have 8 to 10 kids working till about 5:00 p.m. You should be ready to give this extra time to support this initiative. The time that I provide (teaching TLE) is greater and in addition I come (to school) earlier."

Using TLE by a teacher who is not a mathematics specialist

The issue of teaching mathematics and using TLE by teachers who are not mathematics specialists came up during one of the focus groups. This matter is worth attention because a substantial portion of the participants in that group turned out to be non-specialist mathematics teachers. One of these teachers pointed out that the program has a huge potential for teachers without a mathematics background, "people who do not know all the answers." According to this teacher, such teachers cannot and should not be expected to be mathematics experts. Their lack of a mathematics background may make them more suited to a facilitator role and TLE is a wonderful opportunity for them to become such. An issue for these teachers is to know "how to find

information instead of being an expert," whereas before using TLE "the teacher was expected to be an expert."

4. CHANGES IN THE CLASSROOM: EFFECTS ON STUDENTS

Focus group participants "care about (their) students and want them to do well." Hence, teachers' efforts in exploring new technologies and teaching methods practically boil down to a single ultimate goal: helping students to improve. Therefore, it came as no surprise that the question about TLE-related changes in students (transformations in learning patterns and outcomes, students' behavior and attitudes, etc.) stimulated very intense discussion among the teachers. The relevant issues also re-emerged constantly at different stages of consultations.

Teachers saw many positive changes in students after introducing TLE including:

- Improved achievement levels
- Assuming responsibility for their own learning
- Attaining time-management skills
- Developing an ability to concentrate and work hard
- Becoming more disciplined
- Developing team work, leadership and social skills
- Becoming comfortable with computers and developing computer skills
- Developing a taste for learning mathematics

Improved Achievement Levels

As discussed earlier, the majority of participants began using TLE in hopes of raising student achievement. Some teachers thought that their TLE classes did, in fact, show a remarkable increase in achievement in comparison to traditional mathematics classes. For example, one teacher indicated that even though they were of similar ability levels, her "1998-1999 TLE kids did 15% better than the regular kids". Her 1999-2000 class "also does very well, because it is so much more work (for the students)." However, as followed from the consultations, in order to gain credibility among school administrators and the public, these individual "success stories" need to be reinforced by generalized, province-wide data comparing achievement levels of TLE and non-TLE students.

Another teacher told the group that his school had been always below average on achievement results. Last year, however, after incorporating TLE in the mathematics program, his students performed better in mathematics than they did in science. Other teachers reported that in their classes "achievement on the computer is better than on paper". In some schools, teachers even thought that TLE classes' results are so different from ordinary classes that it "even looks suspicious."

The mentioned accounts are drawn mainly from the group with the most enthusiastic and optimistic TLE users. The remaining two groups had a limited number of achievement-related comments and displayed a more cautious stance towards this issue. While some participants reported achievement improvements in their schools and there were no overtly negative comments about student achievement, some teachers noted that it is early to say if there were some achievement changes. The teachers mentioned that achievement is very student-driven and depends on student demographics.

In general, all three focus groups concentrated on other important areas of student improvement associated with using TLE, such as students working harder, developing positive attitudes towards mathematics, attaining social, leadership and time management skills and becoming independent and responsible learners. According to one of the teachers, this type of improvement "is even better than an increase in grades." It became clear from the consultations that a solely achievement-driven approach is not sufficient for assessing the whole range of positive effects of TLE.

Active, Self-directed Learning

According to the focus group participants, a switch to TLE-based mathematics delivery presumes a number of radical changes in students' behavior and attitudes towards learning. Students cease to be passive "recipients of knowledge" and become active and independent learners. Increasingly, students assume responsibility for their own learning including time management, discipline, and communication with each other and the teacher.

Increased Student Motivation

Participants in different focus group came to the same conclusion that *students generally work harder with TLE* than they do in a traditional mathematics class. According to the teachers:

- "TLE makes some kids work hard, which is a positive thing."
- TLE classes do well "because (TLE) is so much more work"

This is a very important implication of using the program, because hard work eventually might result in improvements in achievement. Teachers provided different reasons for students working harder with TLE including enhanced motivation on the one hand and being pressured by a changed classroom environment into "doing something" on the other hand.

TLE challenges the many kids who are already self-motivated. TLE provides more work and practice for such motivated kids than a usual mathematics program. For example, one of the teachers remarked that her TLE students do much more writing and homework than students in an ordinary mathematics class (and normally don't mind this additional work). In addition, TLE makes it possible for gifted students to jump on to higher Grade level material "to explore opportunities" and stay occupied.

Using TLE "Forces" Some Reluctant Students to Work

Focus group discussion suggested that there is not necessarily a direct relationship between students liking TLE and working hard. Some students might detest TLE but still work hard. One teacher, for instance, told the group that some of her students are negative because of the hard work and responsibility for their own learning. For example, one student "hated" TLE because she needed to read step-by-step instructions by herself instead of having the teacher explain everything to her. A teacher from another focus group expressed similar idea: "Several of my kids work harder on mathematics and therefore they don't like it."

As noted by the teachers, TLE is set up so that it is "tricking kids into doing more problem solving," into "doing more stuff." "Some students do not like to use a computer, but …it makes them work." For example, catching up on missed material requires self study with TLE. Students "have to make an effort to catch up instead of simply borrowing notes." In addition, constant quizzes make cheating less appealing, because the results make students quickly "find out for themselves" that they are not learning. "This brought some kids into the honest workers camp."

Teachers from different focus groups rendered the following general comments with respect to a changed classroom atmosphere that promotes work among students:

- "In a traditional classroom if you don't get what is going on, you just sit quietly, in the TLE lab you *at least do something.*"
- "It (TLE) makes a kid do something."
- "The quiet kid suddenly starts to do something on the TLE (he/she can't hide behind the textbook). They just can't hide as they used to."
- "An unfocused kid is immediately recognized by the teacher and by the kids. Thus you are forced to do something, and learning begins to happen."
- "(I) found that those (students) who 'don't like it' are forced to work harder than they have been, to think mathematically, talk mathematically."
- "They (students) are more accountable, more responsible. They know that if they do nothing they will not get anything" (i.e., a mark).

Creative Learning and Problem Solving

Some teachers hoped to enhance qualities such as problem solving ability in their students through the use of TLE. As one of them pointed out, "I think anything you can do to help problem solving will not hurt but will help." He thinks that TLE assists him in this task.

There was no unanimous agreement among the teachers with regard to the development of students' creativity and problem solving capacities as a result of using TLE. Nevertheless, the majority of the teachers who discussed this issue seem to be inclined to the opinion that "the program is good for creative kids" and also for developing creativity and problem solving skills in students in general.

Team Work

A unique feature associated with using TLE is an opportunity to enhance learning cooperation among students through encouraging productive classroom socialization. According to the teachers, the "atmosphere in the classroom changes." "(There is) good socializing, helping each other." "TLE promotes discussion among the students. They are talking about mathematics, while in other classes they are not allowed to talk."

Discipline

Overall the issue of student discipline did not attract a great amount of teachers' attention during the consultations, even when they were asked specifically about the problems associated with using TLE. A large number of the teachers seem to agree, "discipline is less of an issue" in a TLE class or even that there are "no discipline problems at all." Based on the consultations one can infer that students are usually more concentrated and less disruptive in a TLE class than in a traditional mathematics classroom. Some teachers even went so far as to say that "the only problem with discipline is that you cannot make them (students) leave for lunch."

On the other hand, a minority of the teachers expressed an opinion that in terms of discipline there is more room for students to misbehave in a TLE classroom and in some cases discipline even worsened compared to a traditional class forcing teachers to spend more time on classroom management. The teachers attributed these problems mainly to very crowded labs. A generously

spaced computer lab provides less opportunities for disruptive behavior. However, teachers often don't have a choice when it comes to a lab set-up.

Computer Literacy

TLE exposes students to computers and, hence, increases their comfort with this technology. As one of the teachers who had a large proportion of below average children in his mathematics class pointed out, "You just assume that each kid in a rich neighborhood has a computer at home. But this clientele...For the kids that have no technology at home this is a great chance to graduate with this knowledge".

Positive Attitudes Towards Mathematics

The teachers observed that "TLE is (generally) interesting for kids," "kids like TLE", and that students "would be disappointed" if TLE is discontinued. One of the teachers, for example, testified that he started using TLE with Grades 9 and 8, but Grade 7 students were also "all excited about it, although they have never done it." Another teacher mentioned that in her school there was always "a one-way migration" or "a movement into" the TLE mathematics class, but no movement in the opposite direction. One of her colleagues, however, argued that if a deadline for changing courses were not there, there probably also would be some movement out of the TLE classes.

Teachers perceived TLE-induced attitudinal changes in their students, specifically in the areas such as increased confidence and liking mathematics. The teachers provided the following testimonials on this subject:

- "There is more confidence on the part of kids, they are more in control, and they enjoy doing mathematics, mathematics is not so dreadful for them. This is even better than an increase in grades. You never push them to the computer, they do it themselves."
- "Those (students) who hate mathematics will not succeed any way, but it is still the best program compared to the book. Still their attitudes change to at least a neutral attitude to mathematics. There is a positive switch in attitudes."

5. TEACHING TLE IN HETEROGENEOUS CLASSROOMS

All or the vast majority of focus group participants had "mixed," heterogeneous classes consisting of "low-level," "middle-level" and "high-level" students. Some of the teachers reported having classes where the proportion of "low-end" students was higher than in an "average" mathematics class. Therefore the teachers were able to offer useful insights into the specifics of teaching TLE under such heterogeneous conditions.

Overall, based on teachers' comments during the consultations, we can infer that many teachers feel middle-level students benefit the most from using TLE. Some of the teachers, however, were hesitant to give a decisive answer to the question of which students benefit the most from TLE. They said it "varies from day to day" and emphasized that the successful outcomes largely "depends on how good a student is". Good in this context referring not only to academic ability, but also to being self-motivated and responsible. As one of the teachers commented, "Some low kids succeed, some high-end students skip things...there are a variety of outcomes."

The following table summarizes the groups of students teachers feel TLE works well for and those who they feel TLE does not work for.

TLE Works/Doesn't Work for...	
TLE Works Best For:	**TLE Doesn't Work For:**
Agreement • Independent students • Strong readers • Visual learners Unique – group 2 • Middle kids • Highly gifted students • Less focused students • Concrete learners • Multi level classrooms • Distance learners Unique – group 3 • Motivated students • Organized students • Risk takers • Disciplined students • Goal oriented students • Partner/group/cooperative learning	Agreement • Slower or poor readers • Lower-end kids (attitude, motivation and ability) Unique – group 2 • Technology adverse students • "Lazy" high academic students Unique – group 3 • Students who can't stay focused • Students who can't pick out important information • Visually impaired unless they have a way to enlarge it • Students who can't organize materials • Large groups • Kinesthetic learners – need manipulatives as well
How do you Help Those Students?	
• Provide a template • Guidelines • Challenge "faster" students with TLE 10 or more difficult levels • Pairing stronger and weaker students (leaderships) • Choice of switching back and forth between TB and TLE • Modified skills, concepts and assignments • Do younger year programs	

Below-average Students

There was no general consensus among the teachers on the effects of TLE on below average students. Generally everyone seemed to agree that this category of students - even those who have difficulty reading - can benefit greatly from using TLE. Some of the teachers reported targeting specifically "low kids to motivate them" and testified, "it works for some kids," "for kids who are below average it (TLE) is godsend," and "even very low kids make amazing success." The flexible, self-paced learning environment associated with using TLE contributes to students' confidence and motivation and, according to one of the teachers, "helps kids to like mathematics."

Nevertheless, some of the teachers thought that TLE *"is not for all kids."* There were remarks among the teachers such as:

- "I found that my low end is much lower with TLE."
- "There are still some low-end, struggling kids that have not changed."

As one of the teachers put it, "There are groups of students…TLE is totally beyond them…It is not for them for a variety of reasons. We know that there would be no success." Another teacher who had a large proportion of below average students in his mathematics classes echoed this idea by

saying that the "clientele" in his school "is not very compatible with TLE". He reported that in his school "some kids are very low," up to several grades behind, and that he tried to teach grade 9 students the stuff from 3-4 years ago.

It followed from the teachers' statements that, aside from ability issues, it is low maturity and motivation level and unwillingness to accept responsibility for their own learning that makes these below average students bad candidates for using TLE. As reported by one of the teachers, "Low ends do not use worksheets, even do not read questions. (They) do not take the responsibility to follow the procedures."

At the same time, some of the teachers disagreed with this point of view. One of them told his group that TLE "can be used for anybody; (it) depends on how much you blend it." Another teacher further emphasized the point that teachers need to make full use of the flexible TLE program in order to motivate low-end students to learn. She reported putting some of her Grade 9 students on the Grade 8 program. As a result, "they become successful and it also adds to their confidence." Other comments on this issue were as follows:

- "No, I think TLE is very good for low-end students. They can have some of these qualities (i.e., being motivated, responsible, and so on), but they are simply not that bright. They have motivation, and when you don't rush them, they succeed."
- "I have this problem too (some low-end, struggling students), but they are still on computers, while in an ordinary class they are simply sleeping. They are still doing some work."
- "It (putting low kids on TLE) is still better than nothing."
- "In general, the program does more good than harm. Low-end kids work at their own pace and succeed."

Average Students

Focus group participants seem to almost unanimously inclined to the opinion that *TLE works the best for average students* ("people in the middle.") As one of the focus group participants said, it "is the middle level that gets really bumped up." Unlike high-end students who might not be reading all the instructions and going through all the steps, middle-level students might appreciate it when mathematics concepts are explained in detail. It can be inferred from the consultations that according to the teachers' perception, this factor – being a middle-range student – is the greatest predictor of success with TLE. TLE with its flexible learning features "gives average kids many more strategies" to meet their learning needs than an ordinary mathematics program.

Above-average Students

There were two major points of view with regard to the effects of TLE on high-end, gifted students. The majority of teachers pointed out that TLE might be not as good for top students as it is for the mid-level group, but at the same time, it does not hurt them. Gifted students "are not well served (by TLE), but it does OK for them." One of the teachers mentioned that "high-end kids are usually very linear and are happy with their textbook." Other teachers observed that high-end students might be annoyed and frustrated by step-by-step TLE instructions. "It is too slow for them." "Gifted students are very impatient." Nevertheless, the teachers concluded that some above-average students can benefit from TLE as "they are still learning." For example, "even if the students are bored, they still have lots to explore, they learn more than when they are just sitting and waiting for you to explain a basic concept." Also, besides learning mathematics, these students may learn other skills with TLE, such as leadership and team-work, especially in classes where they are encouraged to

help other students. One of the focus group participants, while acknowledging that mid-level students benefit the most from TLE, concluded that her high or low end "is not getting any lower" either.

Another opinion held by some of the teachers was that TLE is an *excellent* learning source for high-end kids because it "allows them to go on a higher level" and thereby further develop their skills and knowledge on their own without being held back. As a result, according to one of the teachers, her "higher group has 10% higher achievement than they used to have."

As with students of other ability levels, motivation plays a role in how above-average students do on TLE. According to the teachers, some of "gifted" students are not highly motivated. The "program does not help (students who are) gifted but lazy." Teachers talked about handling this problem by giving high-end students "something rewarding, challenging." For example, some teachers challenged fast students to go one grade higher to explore further opportunities. There are a number of other "very motivating options," such as helping others, working on homework, or marking papers from lower grades.

6. SUCCESSFUL TLE TEACHING PRACTICES

Focus group participants' accounts of their successful experiences with teaching TLE are closely associated with previously outlined themes related to the teacher's role in the classroom and the effects of using TLE on students. The present section, however, focuses on specific examples of successful TLE teaching practices.

Teachers pursued the following major goals in their teaching practices:

- Creating a stimulating and inclusive learning atmosphere in their classrooms by fostering work among students and blending different learning styles
- Ensuring that the students are "making the most" of their classroom time
- Creating opportunities of constant evaluation and monitoring of students' progress
- Creating a relaxing, "non-threatening" learning environment.

Not surprisingly, sometimes there was no consensus among the teachers about which TLE practices are particularly successful. For example, the teachers showed different attitudes towards the utility and applicability of student evaluation. These "discrepancies" can be attributed to variations in teaching and learning styles and the flexible nature of TLE, which would not provide "universal remedies" but instead would allow each teacher to make adjustments to the learning needs of students.

Blending

Focus group participants, regardless of the percentage of time devoted to TLE in their classrooms, favored different *blended approaches* to teaching TLE. As noted by one of the teachers, "A combination of methods is useful." "Don't be afraid to use it (TLE) as a blend! It is not necessary to use it as a primary resource. Nelson also realizes that blended approach could be the best."

Focus group participants generally agreed upon the usefulness of supplementing computer-based teaching with more conventional pencil-and-paper and board work. As one of the teachers explained, "The computer does not allow you to work *all* things out. You still need a pencil-and-

paper. I still want them (students) to take some notes for practice and for Achievement Tests." His colleague stressed the issue of students' preparedness for high school mathematics, which most probably would be delivered in a traditional way: "We should reinforce the value of pencil-and-paper, so that if there is no TLE next year, they are ready for it." Also, according to some of the teachers, each year there is a small group of students who "just do not like computers." Thus it is reasonable to assume that a combination of computer-based and non-computer learning makes it possible to attain an "optimal" balance between different students' learning needs and preferences.

Teachers considered note journals that go along with the computer lessons for students to be really helpful learning tools.

Individualizing Learning and Establishing Familiar Routines

Teachers talked about the benefits of using the flexibility of TLE to tailor teaching in accordance with the needs of particular students or groups of students. One teacher, for example, developed "a whole package for each kid's work." As a result, students are able to work independently and at their own pace on these individual packages. This teacher gives her students "a worksheet with definitions" and encourages them do a self-check. When they have completed work in class, they can proceed with working on their homework sheets.

An interesting approach to teaching heterogeneous classes that becomes available to the teachers as a result of using TLE can be labeled "cross-grade teaching." Some teachers reported helping weaker students by putting them on a lower grade and encouraging and challenging faster students by offering them a higher grade level. While one of the teachers commented "if you have a child in grade 9 and teach him grade 7 TLE, it means that formally you are not teaching the curriculum," others reported doing these back and forth switches very successfully.

Another teacher organized her TLE class in a very interesting and innovative manner in order to enhance individualized instruction. In her class "smart, independent students work on projects in a (separate) group independently." It makes it possible for her "to concentrate more on low and medium kids and make the class smaller." As a result, fast top students don't feel bored and the students who need more individual attention get it. "They (slower students) don't feel so stupid and they like that I focus on them more."

Assessment

The assessment issue was brought forward on many occasions during the focus groups. There was a substantial split in teachers' opinions on this matter. Some of the teachers were in favor of creating a relaxing and process-oriented rather than results-oriented learning atmosphere for their students. "Do not make expectations too high to discourage kids, scare them off." "Self-checks towards their marks? I do not use it at all. (Instead) I try to encourage them...the best thing for the brain to make it work is high challenge and low risk. Nobody looks over his or her shoulder."

Other teachers, on the contrary, stressed the value of using different assessment tools, which would make it possible to monitor students' progress. For example, one of them reported the value of self-checks and doing quizzes after each lesson. His students are expected to do paper exams in the end, in part because a paper quiz makes it possible for the teacher to check students' real understanding of the material.

There was general agreement, however, that students should not perceive assessment as a threat or punishment. The teachers expressed the following ideas with regard to this issue. "Students are concerned about marks. It is important to emphasize to the students that skill checks are necessary and they don't involve punishment." "Let them (students) know that if they make a few mistakes, it will not cost them their grade."

Social Skills

As mentioned earlier, TLE provides students with opportunities to cooperate with each other and "talk mathematics." However, creating a social atmosphere in the classroom and making it productive largely depends on the teacher. According to the focus group participants, a teacher needs to identify students that want or need to work together and encourage them to help each other. The teachers provided many examples of successful practices that could facilitate students' discussion and cooperation. Some teachers put two students on one computer to work though lessons but have them do self-checks on an individual basis. Some introduced a principle: "When you have a problem, the first person to talk to is your neighbor." Some change sitting arrangements periodically to facilitate the discussion.

The teachers thought that a socially charged classroom atmosphere motivates students, makes them verbalize mathematics concepts, work together, share, and develop social and leadership skills. The teachers commented on the resulting major changes in their classrooms in the following way:

- "They (students) communicate much more and are more involved. (Using TLE) makes them better communicators verbally. (Kids) talk 60 to 70% more than in a normal classroom."
- "My classroom is not quiet any more, and *they are talking mathematics.* It is 'talk-and-work'."

Dealing with Classroom Problems

The teachers admitted that cheating could be a common problem in a TLE classroom. "Students can get good marks by guessing if TLE is not used properly." However, they also mainly agreed, "it is not a TLE issue." "The same students can bring answers from the back of the book." "It is not different from textbooks. Issues with cheating and weak kids are the same." According to the teachers, regular pen-and-paper quizzes may discourage students from cheating because they make students realize that they are not learning or making progress and will eventually get a poor grade.

Some of the focus group participants indicated that students' interest and enthusiasm might eventually fade in a TLE classroom - especially after students realize how much work they need to do with TLE. As one of the participants commented, "I noticed that at first the productivity of students was really high, but then towards Christmas enthusiasm falls." He handled this issue by switching from teaching TLE full-time to using it part-time. His colleagues shared other strategies to trigger students' motivation including reducing the pace "to allow them to keep up," and mixing up teaching strategies.

7. ISSUES WITH IMPLEMENTING TLE

There are almost unavoidable challenges associated with teachers' and students' adjustment to TLE. Teachers' accounts include being "not comfortable with TLE for quite some time," and coping with the increase in work which was universally noted by all teachers. Issues faced by TLE teachers also include those that would likely be faced in any classroom situation. For example, the majority of

teachers – TLE and non-TLE - would encounter the challenges associated with teaching in heterogeneous classes.

Difficulties associated with implementing TLE were largely already touched upon in preceding sections of this report. Here we highlight and summarize some of the previously addressed issues as well as provide additional information that was not included in the foregoing sections. Based on teachers' accounts of their classroom experiences, the problems associated with teaching TLE can be grouped into the following categories:

(1) Technical problems
(2) Curriculum and continuity issues
(3) Administrative, collegial and parental supports
(4) Time issues
(5) Student-related issues
(6) Teacher-related issues
(7) Rural schools

Technical Problems

Besides the problems with hardware and lab set-up (which are discussed in "Supports Needed" section), technical issues that concerned the teachers were associated with the TLE software package. According to the teachers, there are still difficulties with the software. The first set of problems included bugs, glitches, and errors in programming (script errors), especially with animation. Teachers noted that students were frustrated with computer "mishaps" such as getting wrong answers. In some cases, students' assignments were not being properly saved by the program. One of the teachers mentioned that the component of TLE that tracks student work does not seem to properly function on Mac systems. Some teachers expressed frustration about additional money charged by the software provider for upgrading as well as about a lack of on-going support from Nelson.

Curriculum and Continuity

During the consultations teachers touched upon some curriculum-related issues that, in their opinion, might detract from the successful implementation of TLE-based mathematics. For one, it is difficult to alter TLE for students on a modified program. In addition, there are "huge curriculum differences between grades 9 and 10." "It is mostly a jump to grade 10. It is very little of what they (students) are doing in grade 9." For example, there are "so many radicals starting grade 10. It throws them (students) off." As far as using TLE is concerned, in many cases its use stops after grade 9 and is not extended to grade 10. Therefore, besides the necessity to make substantial adjustments to a new demanding curriculum, students need to switch from computer-based mathematics back to textbooks. This transition was a matter of concern for some of the students and parents and makes it less likely they will be accepting of TLE at the junior high school level.

The teachers expressed different views on how to handle student transitions back to textbooks. To start with, one of them argued, "for students who are self-motivated, are self learners, it (transition to grade 10) should not be tough. It is those who simply click to get (guess) answers that fall through cracks." It followed from the discussions that TLE not leading to grade 10 curriculum should not be an issue if the program is used only as a supplement. One teacher reported starting

"introducing a little bit grade 9 students to grade 10 stuff" in order to make them more prepared for the forthcoming changes.

Administrative, Collegial and Parental Supports

Collegial and administrative supports (along with technical support issues) generated utmost concern among TLE teachers. As outlined in the "Supports Needed" section, some focus group participants were concerned about the lack of administrative and parental support. Problems of collegial support were mainly focused on the lack of support and understanding on the part of high school teachers. Teachers considered lack of information to be the major source of these issues. In addition, high school curriculum modifications make it less likely that high school teachers will embrace TLE because they have already undergone a great deal of change.

Time Issues

The increased workload – for both teachers and students - generated concern among teachers and was discussed on many occasions in various contexts. First of all, as mentioned earlier, using TLE usually increases teachers' workload, which, in turn, results in a general time shortage for the teachers. The teachers mentioned needing to put in a lot of extra time for supplementary teaching including during lunchtime and after school. A second time-related issue was teachers' ability to accommodate the volume of the program into the limited time available. The teachers indicated that in particular, the grade 9 curriculum is very voluminous. At the same time, given that using TLE often includes individualized, one-on-one work with students and also encouraging the latter to work at their own pace, some teachers have difficulties covering all the material. As one of the teachers pointed out, "We don't have enough time. We are behind terribly. I am behind more and more..."

The time shortage is exacerbated by the fact that planning a schedule for TLE lessons differs from planning for a regular class. As with some of the other TLE implementation issues, this could be addressed by providing new TLE teachers with additional information on scheduling lessons.

Student-related Issues

As discussed earlier, the following student-related issues can interfere with teaching TLE:

- The teachers agreed that TLE is not good for immature, unmotivated and irresponsible students (whether they are top or below average students).
- Students who had problems with mathematics prior to using TLE can also have problems with TLE.
- There are always some students in the class who won't embrace computers. "Some students just don't want to use the machine (any use, whether word processing or TLE). The perception that every kid likes technology is not true. Not many of them though are 'computer phobic.' They either loved it or hated it, no middle ground."
- Some students prefer textbooks and a teacher lecturing.
- Some students don't appreciate one-on-one instruction and work in small groups (it does not work for some students).
- Some students (especially in Grade 7) have reading problems that make it difficult for them to use TLE, which requires a lot of reading. TLE only provides limited audio and "some kids are very self-conscious about using audio."

- Some students don't have a computer at home. In this case after school computer time should be available for them to catch up and do their homework.
- Sometimes students don't realize that they are learning a lot on the computer ("perception that you are learning on the computer... It is just yet not there.") Therefore, some of them may not be serious about computer-based mathematics.
- In some classes attendance and turnover are big problems. According to the teachers who teach such classes, "some kids disappear for 1.5 months and then come back. (We are) backtracking all the time." Also, some students don't come to supplementary labs which makes them unable to catch up.

Teacher-related Issues

In terms of a teacher making a decision to start using TLE, the focus group participants thought that TLE "is not for everyone." The focus group participants thought that a lot depends on the teacher to make the program a success: "The program is as good as a person using it." "It is what you put into it." The teachers put forward the following teacher-related issues as the conditions of successful TLE teaching:

- "The teacher has to really want to do it." If a teacher has a negative attitude towards TLE, students pick up on this very quickly.
- The teacher should be aware of the amount of preparation involved with TLE and also be willing and able to adapt to a completely new mode of teaching. A teacher might have knowledge of the mathematics program, but with TLE he/she needs to switch to a completely new teaching style (e.g., being a facilitator, being able to give more control to students and being able to work one-on-one with the latter). "If you can't change and adapt, this program is not for you."
- As noted by one of the teachers, there are some transients among the teachers who change their areas of expertise and careers. Therefore, such "teachers are not necessarily the best decision-making source" with regard to whether and how to use TLE.
- Lack of technical literacy on the part of the teacher might interfere with TLE implementation.

Rural Schools

Although a set of the TLE-related issues was similar for all three focus groups, the consultations uncovered that the relative importance of these issues was different for urban and rural schools. These problems involve a variety of areas including costs of equipment, costs of software upgrading, costs of maintenance and costs of in-service. Another big issue with rural teachers was the lack of accessibility to training services.

Overall, teachers from rural schools perceived themselves as being isolated, away from mainstream information sources and service facilities. In addition they perceived their schools to be deprived of sufficient funding and felt that more financial resources were allocated in urban areas. They appealed to the government and to Nelson to pay more attention to rural jurisdictions in terms of supporting TLE.

8. TEACHERS' PERSONAL GAINS

Contrary to our expectations, the teachers did not provide much direct feedback on their personal gains as a result of using TLE. It was difficult to make the teachers reflect more on themselves than on their students - the conversation typically turned to the latter and how they can benefit from the program. However, it was clear from the consultations that the teachers did make some personal gains as a result of using TLE.

The teachers mentioned two major types of benefits from using TLE. First, using TLE can contribute to their professional development, including mastering new teaching strategies, learning alternative ways of controlling the class, attaining a better understanding of some mathematics concepts, and developing knowledge in computers and technology.

Many of the teachers thought that they had enhanced their computer and technological literacy through using TLE. Some of them thought that they "learned more about computers," and that TLE made them "much more comfortable with using computers" in general.

In addition, the focus group participants said that being "a new tool," TLE "makes you utilize and enhance your skills as a mathematics teacher." This may be both learning new teaching skills and attaining additional knowledge about the subject. One teacher reported starting to understand some mathematics concepts better by seeing them on the computer. Her colleague felt that TLE helped him "to give the students a new way to look at mathematics problems" and at the same time "allowed me to figure out something for myself."

The teachers reported learning a lot and looking forward to expanding their knowledge, including learning more teaching methods and styles. There were a number of remarks on this subject including:

- "This (using TLE) was a change that made me do things differently ('woke me up'), and it is a good thing for kids."
- "You learn more techniques and styles."
- "One day you are a lecturer, another day you are a facilitator. (It is) different from day to day."
- "I think it (TLE) is a wonderful learning source. I enjoy it and I am still learning."
- "I was surprised how much I have learned."

As summarized by one of the participants, the opportunity to expand teaching expertise and flexibility associated with using TLE "makes me a better teacher."

In addition to professional growth, the teachers mentioned the personal benefits they had gained from using TLE. Teachers develop a sense of accomplishment and satisfaction by introducing new technology and teaching methods in their classes and by helping their students succeed. Personal gains also included increased communication with the students. "I am very happy. Three-year growing pains had to be there. Now I have everything to make it effective and efficient. I am giving (students) traditional approaches and new methods."

9. SUMMARY

Overall, teachers were very positive about their TLE experiences and thought that their students were benefiting from this new form of instructional delivery. Many perceived positive attitudinal changes in their students. In addition, they thought that both they and their students benefited from the opportunity to employ creative and innovative teaching strategies. TLE allows students to work at their own pace and provides teachers with an opportunity for more one-on-one and small group instruction. The vast majority of focus group participants agree that TLE works best for mid-level students. There was some concern that it was not ideally suited to other groups such as below average and modified program students.

While teachers were generally happy about what is occurring in their classroom, many thought that additional supports are needed. Almost uniformly, teachers thought that both Alberta Learning and Nelson could facilitate more effective communication within the TLE community. In addition, schools without adequate technical support were finding TLE implementation very difficult. For those who had adequate support, however, TLE offered an opportunity to bring a new and exciting form of learning to the classroom.

Appendix 1 – Methodology

Sampling Frame

The sampling frame for the study consisted of all schools that:

- according to Nelson Canada records, had purchased 4 or more copies of TLE[12].
- had more than 10 grade 9 registrations in 1999/2000
- eligible to be 100% funded through Alberta's K-12 system (i.e. private, post-secondary and band schools are excluded)

This resulted in a list of 137 schools. Schools were then selected in a manner designed to maximize the TLE sample. Primarily, schools that had purchased a significant number of copies of TLE 9 in comparison to their grade 9 student population (approximately 1:3) were called. In addition, schools with a lower proportion of TLE 9 copies but with a high student population were called because of the probability that they were using TLE for selected classes.

Schools were phoned to determine if they had any grades/classes where TLE was used with all of the students. Schools were then asked to provide class lists to identify students using TLE, if necessary[13]. TLE teachers were interviewed to determine exactly how and for what proportion of time they were using TLE. In addition, teachers were asked questions about their own TLE experience including training and number of years using TLE.

Within the school/class, only students who were registered in the school in grade 9 on September 30th, 1999 *and* who wrote the Achievement Test in the school in June 2000 were included in the *achievement* analysis. This limited the analysis to students who had received TLE instruction for the entire school year.

Schools using TLE in the 2000/2001 school year were also asked to participate in the student attitudes portion of the study. In addition, schools that were not using and had never used TLE were asked to participate as a control group.

Teachers from all 137 schools were also sent focus group invitations. All teachers who were currently using, or who had used, TLE were invited to participate.

Student Achievement Analysis

The relationship between TLE and students' academic achievement was examined using the 1996/1997 Mathematics 6 and 1999/2000 Mathematics 9 Provincial Achievement Tests. The research design attempted to isolate the effect of TLE by using students' prior, non-TLE achievement (grade 6) to predict their post-TLE achievement (grade 9). Using linear regression, individual students' Grade 6 Provincial Achievement Test scores were used to predict their Grade 9 Achievement Test scores. This technique allows us to examine students grade 9 achievement net of their prior (grade 6) achievement. Provincial Achievement Test data provided a timely, cost-effective and standardized measure of student performance.

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[12] The requirement that schools purchase at least 4 copies was included to remove schools that had either only purchased evaluation copies or were just using TLE for limited, remedial instruction from the sample.

[13] Alberta Learning's FOIPP coordinator provided the opinion that the evaluation of a particular program is a valid reason for disclosing students' personal information.

Student Attitudes Analysis

In order to investigate the effect of using TLE on students' attitudes towards mathematics, students using TLE for the first time and students in control schools (i.e. students who were not using TLE) were administered a survey. In order to measure initial attitudes towards mathematics, a pre-test was administered in the first week of September 2000. The post-test was administered during the week of April 30th – May 4th, 2001.

Control schools were selected based on their similarity to participating TLE schools and, of course, on their willingness to participate in the study. Control schools were matched on the following characteristics:

- Size of student population
- Size of grade 9 student population
- % Achieving the acceptable standard – 1999 Grade 9 Mathematics PAT
- % Achieving the standard of excellence – 1999 Grade 9 Mathematics PAT
- Average (mean) score - 1999 Grade 9 Mathematics PAT

Appendix 2 – Student Survey (Pre-test)

ALBERTA LEARNING MATH ATTITUDES SURVEY

Instructions

The Department of Learning is conducting a study to find out how students feel about math. The results of this study will be used to provide information on ways to help students learn math. Therefore, it is very important that you answer the questions as openly and honestly as possible. Remember, there are no right or wrong answers; we are only interested in your opinions and experiences. Your answers will be completely anonymous; this means that we will not show your answers to teachers, parents or any other people. Thank you very much for answering the survey.

Please fill in your answers on the provided green answer sheet by completely filling in the circle in **pencil**. Even if you circle the responses on this question sheet, make sure that you also fill out the answer sheet, as that is what we will be looking at.

First, tell us a few facts about yourself.

Birth Date	On what date were you born? (Fill in the circles that match the month, day, and last two figures your birth year in the Birth Date section of the answer sheet)
Gender	Are you a boy or a girl? (Please fill in one circle - M if you are a boy and F if you are a girl - in the Sex section of the answer sheet)
Grade	What Grade are you in? (Please fill in one circle in the Grade section of the answer sheet)

To answer the rest of the questions, please go to the right hand side of your answer sheet. Find the row of circles with the same number as the question you want to answer. In this row fill in the circle that matches the answer number that you have chosen. For example, to answer question 1 you should go to row 1 on your answer sheet. If you choose to answer, "Yes" to question 1, you would fill in the circle with a 1 in it, if you answer "No", fill in the circle with a 2 in it.

1.	Do you have a computer at your home?	1 Yes	2 No	
2.	Outside of class time (meaning such times as at lunch, after school, at home, etc.), approximately how often do you use a computer?	Never – fill in circle 1 1 to 3 times a week – fill in circle 2 4 to 5 times a week – fill in circle 3 6 or more times a week – fill in circle 4		
3.	Outside of math class, how often do you study or do math homework?	Never – **fill in circle 1** Rarely: less than once a week– **fill in circle 2** Sometimes: 1-2 times a week – **fill in circle 3** Often: more than 2 times a week – **fill in circle 4**		
4.	Did you use The Learning Equation (TLE) computer program in math last year or the year before?	**1** **Yes**	**2** No	3 Used a math computer program – not sure which one

People have different experiences studying math. Please describe how you feel about math by coloring in one number on the answer sheet for each of the following statements to show how much you agree or disagree with them.

		STRONGLY DISAGREE	DISAGREE	NEUTRAL	AGREE	STRONGLY AGREE
5.	I usually do well in math	1	2	3	4	5
6.	Math is boring	1	2	3	4	5
7.	To do well in math, **all** you need to do is memorize facts	1	2	3	4	5
8.	I do not like going to math class	1	2	3	4	5
9.	Math is important in everyday life	1	2	3	4	5
10.	Math makes me feel confused	1	2	3	4	5
11.	Everyone can do math if he/she tries hard enough	1	2	3	4	5
12.	Math is important only to math teachers	1	2	3	4	5
13.	Math is fun	1	2	3	4	5
14.	Math is harder for me than for most people	1	2	3	4	5
15.	It is important to do well in math at school	1	2	3	4	5
16.	I try to explore different ways to solve a math problem	1	2	3	4	5
17.	I feel I will do better in math this year	1	2	3	4	5
18.	Math is one of my most dreaded subjects	1	2	3	4	5
19.	I have been successful in solving difficult math problems	1	2	3	4	5
20.	Usually, when I do not know the answer to a question right away, I try to guess	1	2	3	4	5
21.	I think I will need to do well in math to get a good job	1	2	3	4	5
22.	No matter how hard I try, I cannot understand math	1	2	3	4	5
23.	I spend as much time as it takes on a problem in order to complete it	1	2	3	4	5
24.	I like math	1	2	3	4	5
25.	Math is a difficult subject for me	1	2	3	4	5
26.	I am as good at math as most other students	1	2	3	4	5

		STRONGLY DISAGREE	DISAGREE	NEUTRAL	AGREE	STRONGLY AGREE
27.	Others could ask me a math question and I could usually answer it	1	2	3	4	5
28.	Usually, when I do not know the answer to a question right away, I try to figure it out	1	2	3	4	5
29.	I am not the type to do well in math	1	2	3	4	5
30.	If a math assignment is too hard, I often stop working on it altogether	1	2	3	4	5
31.	I am confident that I will obtain a 65 or better in math	1	2	3	4	5
32.	Math is not very important outside of school	1	2	3	4	5

The next two statements relate to computers. Please tell us how you feel about using computers by coloring in one number on the answer sheet for each statement.

		STRONGLY DISAGREE	DISAGREE	NEUTRAL	AGREE	STRONGLY AGREE
33.	I like using computers	1	2	3	4	5
34.	I am good at using computers	1	2	3	4	5
35.	Computers make me nervous and uncomfortable	1	2	3	4	5

The following four statements refer to what your friends and family members think about math. Please describe how you feel about each statement by coloring in one number on the answer sheet to show how much you agree or disagree with the statement. If a situation does not apply to you, please select the "does not apply" choice.

		STRONGLY DISAGREE	DISAGREE	NEUTRAL	AGREE	STRONGLY AGREE	DOES NOT APPLY
36.	One or both of my parents/guardians think(s) learning math is important	1	2	3	4	5	6
37.	One or both of my parents/guardians say(s) that if I am not successful in math, I should focus on other subjects where I have more ability	1	2	3	4	5	6
38.	One or both of my parents/guardians would be able to help me with my math homework if I asked	1	2	3	4	5	6
39.	My friends think it is important for me to do well in math	1	2	3	4	5	6

Choose ONE OR MORE answers for questions 40 and 41 - color in as many numbers as apply to you on the answer sheet.

40. How do you like to be taught in math class? **(color in all that apply)**

1 Teacher instructing the entire class

2 Teacher instructing small groups

3 Small groups working on their own, with minimal help from the teacher

4 Teacher helping individual students, one at a time

41. *How do you like to work on math?*
(color in all that apply)

1 With the teacher
2 In cooperation with my classmates (with a partner)
3 On my own (individually) in class
4 On my own (individually) at home
5 With help from my parents/guardians

42. Are you using The Learning Equation (TLE) computer math program in math class this year?
(If you answer YES to this question you should go on to answer questions 43 – 47, if you answer NO, skip questions 43 – 47)

1 Yes (Answer questions 43-47)	2 No (Go directly to question 48)

		STRONGLY DISAGREE	DISAGREE	NEUTRAL	AGREE	STRONGLY AGREE
43.	I am looking forward to using computers in my math class this year	1	2	3	4	5
44.	Using a computer in math class will be fun	1	2	3	4	5
45.	Using a computer in math class will help me learn math	1	2	3	4	5
46.	I don't want to use a computer in math class	1	2	3	4	5
47.	I don't think I will do well in a math class that uses computers	1	2	3	4	5

Now go to Question 48

48. If you have any additional comments about studying math, please write them in the space below.

Appendix 3 – Student Survey (Post-test)

ALBERTA LEARNING MATH ATTITUDES SURVEY

Instructions

The Department of Learning is conducting a study to find out how students feel about math. The results of this study will be used to provide information on ways to help students learn math. Therefore, it is very important that you answer the questions as openly and honestly as possible. Remember, there are no right or wrong answers; we are only interested in your opinions and experiences. Your answers will be completely anonymous; this means that we will not show your answers to teachers, parents or any other people. Thank you very much for answering the survey.

Please record your answers on the provided green answer sheet by completely filling in the circle in **pencil**. Even if you circle the responses on this question sheet, make sure that you also fill out the answer sheet, as that is what we will be looking at.

First, tell us a few facts about yourself.

Birth Date On what date were you born?
(Fill in the circles that match the month, day, and last two figures of your birth year in the Birth Date section of the answer sheet. If your birth day is only one digit – e.g. 4 – please fill that in as 04. For example, if your birth date is January 9th, 1987 you would fill in the circle marked Jan., fill in 09 for the day and fill in 87 for the year.)

Gender Are you male or a female?
(Please fill in one circle - M if you are a male and F if you are a female - in the Sex section of the answer sheet)

Grade What Grade are you in?
(Please fill in one circle in the Grade section of the answer sheet)

To answer the rest of the questions, please go to the right hand side of your answer sheet. Find the row of circles with the same number as the question you want to answer. In this row fill in the circle that matches the answer number that you have chosen. For example, to answer question 1 you should go to row 1 on your answer sheet. If you choose to answer, "Yes" to question 1, you would fill in the circle with a 1 in it, if you answer "No", fill in the circle with a 2 in it.

49. Do you have a computer at your home?
1 Yes (fill in circle 1)
2 No (fill in circle 2)

50. Outside of class time (meaning such times as at lunch, after school, at home, etc.), approximately how often do you use a computer?
Never – **fill in circle 1**
1 to 3 times a week – **fill in circle 2**
4 to 5 times a week – **fill in circle 3**
6 or more times a week – **fill in circle 4**

51. Outside of math class, how often do you study math or do math homework?
Never – **fill in circle 1**
Rarely: less than once a week– **fill in circle 2**
Sometimes: 1-2 times a week – **fill in circle 3**
Often: more than 2 times a week – **fill in circle 4**

52. Did you use The Learning Equation (TLE) computer program in math last year or the year before?
1 Yes
2 No
3 Used a math computer program – not sure which one

People have different experiences studying math. Please describe how you feel about math by filling in one circle on the answer sheet for each of the following statements to show how much you agree or disagree with them.

		STRONGLY DISAGREE	DISAGREE	NEUTRAL	AGREE	STRONGLY AGREE
53.	I usually do well in math	1	2	3	4	5
54.	Math is boring	1	2	3	4	5

		STRONGLY DISAGREE	DISAGREE	NEUTRAL	AGREE	STRONGLY AGREE
55.	To do well in math, **all** you need to do is memorize facts	1	2	3	4	5
56.	I do not like going to math class	1	2	3	4	5
57.	Math is important in everyday life	1	2	3	4	5
58.	Math makes me feel confused	1	2	3	4	5
59.	Everyone can do math if he/she tries hard enough	1	2	3	4	5
60.	Math is important only to math teachers	1	2	3	4	5
61.	Math is fun	1	2	3	4	5
62.	Math is harder for me than for most people	1	2	3	4	5
63.	It is important to do well in math at school	1	2	3	4	5
64.	I try to explore different ways to solve a math problem	1	2	3	4	5
65.	I feel I will do better in math this year	1	2	3	4	5
66.	Math is one of my most dreaded subjects	1	2	3	4	5
67.	I have been successful in solving difficult math problems	1	2	3	4	5
68.	Usually, when I do not know the answer to a question right away, I try to guess	1	2	3	4	5
69.	I think I will need to do well in math to get a good job	1	2	3	4	5
70.	No matter how hard I try, I cannot understand math	1	2	3	4	5
71.	I spend as much time as it takes on a problem in order to complete it	1	2	3	4	5
72.	I like math	1	2	3	4	5
73.	Math is a difficult subject for me	1	2	3	4	5
74.	I am as good at math as most other students	1	2	3	4	5
75.	Others could ask me a math question and I could usually answer it	1	2	3	4	5
76.	Usually, when I do not know the answer to a question right away, I try to figure it out	1	2	3	4	5
77.	I am not the type to do well in math	1	2	3	4	5
78.	If a math assignment is too hard, I often stop working on it altogether	1	2	3	4	5
79.	I am confident that I will obtain a 65 or better in math	1	2	3	4	5
80.	Math is not very important outside of school	1	2	3	4	5

The next three statements relate to computers. Please tell us how you feel about using computers by filling in one circle on the answer sheet for each statement.

		STRONGLY DISAGREE	DISAGREE	NEUTRAL	AGREE	STRONGLY AGREE
81.	I like using computers	1	2	3	4	5
82.	I am good at using computers	1	2	3	4	5
83.	Computers make me nervous and uncomfortable	1	2	3	4	5

The following four statements refer to what your friends and family members think about math. Please describe how you feel about each statement by filling in one circle on the answer sheet to show how much you agree or disagree with the statement. If a situation does not apply to you, please select the "does not apply" choice.

		STRONGLY DISAGREE	DISAGREE	NEUTRAL	AGREE	STRONGLY AGREE	DOES NOT APPLY
84.	One or both of my parent(s)/guardian(s) think(s) learning math is important	1	2	3	4	5	6
85.	One or both of my parent(s)/guardian(s) say(s) that if I am not successful in math, I should focus on other subjects where I have more ability	1	2	3	4	5	6
86.	One or both of my parents/guardians would be able to help me with my math homework if I asked	1	2	3	4	5	6
87.	My friends think it is important for me to do well in math	1	2	3	4	5	6

Choose ONE OR MORE answers for questions 40 and 41 - fill in as many circles as apply to you on the answer sheet.

88. How do you like to be taught in math class?
(fill in all circles that apply)

1 Teacher instructing the entire class
2 Teacher instructing small groups
3 Small groups working on their own, with minimal help from the teacher
4 Teacher helping individual students, one at a time

89. How do you like to work on math?
(fill in all circles that apply)

1 With the teacher
2 In cooperation with my classmates (with a partner)
3 On my own (individually) in class
4 On my own (individually) at home
5 With help from my parent(s)/guardian(s)

90. Did you use The Learning Equation (TLE) computer math program in math class this year?
(If you answer YES to this question you should go on to answer questions 43 - 67, if you answer NO, go on to question 68)

1 Yes **(Please answer questions 43-67)**	2 No (DO NOT answer questions 43-67 Go to question 68)

This group of questions asks about your experiences with using The Learning Equation (TLE) computer program in your math class this year. Please fill in one circle on your answer sheet for each question.

91. On average, how many math classes (i.e. periods) do you have in 1 week? _____ (fill in the circle on the answer sheet that corresponds with the number of classes)

92. Looking back over this school year, on average, how many times in a week did you use TLE in math class?
- less than 1 class a week–**fill in circle 1**
- 1 or 2 classes a week–**fill in circle 2**
- 3 classes a week–**fill in circle 3**
- more than 3 classes a week-**fill in circle 4**

93. Looking back over this school year, when you worked on TLE in math class, how many students did you typically share the computer with?
- None – I worked alone–**fill in circle 1**
- 1 other student–**fill in circle 2**
- more than 1 other student–**fill in circle 3**

94. Outside of math class time (meaning such times as lunch, after school, at home, etc.) approximately how often do you use TLE?
- Never – **fill in circle 1**
- Rarely: less than once a week– **fill in circle 2**
- Sometimes: 1-2 times a week – **fill in circle 3**
- Often: more than 2 times a week – **fill in circle 4**

The next section of the survey asks you to think about your experiences using TLE. Please indicate the extent to which you agree or disagree with the following statements by filling in one circle on the answer sheet for each statement.

		STRONGLY DISAGREE	DISAGREE	NEUTRAL	AGREE	STRONGLY AGREE
95.	I often had to share a computer when I did not want to	1	2	3	4	5
96.	Using TLE makes me feel more comfortable around computers	1	2	3	4	5
97.	The computers were too slow	1	2	3	4	5
98.	The computers often crashed (i.e. were not working)					
99.	Using computers for math allows students to work together to help each other	1	2	3	4	5
100.	Computer related (i.e. technical) problems interfered with my work in math class	1	2	3	4	5
101.	I did better in math this year because of TLE	1	2	3	4	5
102.	Using computers in math has helped me better understand math	1	2	3	4	5
103.	I like using TLE because it helps me to learn math more quickly	1	2	3	4	5
104.	I receive more individual attention from the teacher during TLE math than I did in regular math class	1	2	3	4	5
57.	I find it hard to complete my work in TLE math class because there are too many distractions	1	2	3	4	5
58.	Using TLE makes me feel more comfortable with math	1	2	3	4	5
59.	I don't like using computers in my math class	1	2	3	4	5

		STRONGLY DISAGREE	DISAGREE	NEUTRAL	AGREE	STRONGLY AGREE
60.	I like the special features of computer math lessons, such as color and sound	1	2	3	4	5
61.	Using TLE has made me better at using computers	1	2	3	4	5
62.	I like regular math lessons more than TLE	1	2	3	4	5
63.	It is difficult for me to do TLE because there is too much reading	1	2	3	4	5
64.	There is too much work to do in TLE	1	2	3	4	5
65	Using a computer to do math is easier than using a textbook	1	2	3	4	5
66.	I would like to use TLE again next year	1	2	3	4	5

The next two questions refer to the note taking you may have done while using TLE.

67. a)	Did you write TLE notes or keep a TLE journal?	**1** (YES)	**2** (NO)

If you answered yes to question #67 a), please answer question #67 b). If you answered, no, please go on to question #68.

67. b)	Did taking TLE notes/keeping a TLE journal help you to better understand math?	**1** (YES)	**2** (NO)

Additional Comments

68. If you have any additional comments, please write them in the space below.

Thanks for completing the survey!

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